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Implementation Study in Microcomputer Technology in Science Education

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research, for acceptance, a thesis entitled "Implementation Study in Microcomputer Technology in Science Education" submitted by Robert A. Abell in partial fulfilment of the requirements for the degree of Doctor of Philosophy.

DEDICATION

This dissertation and the degree
for which it was presented
is dedicated to my family

Evelyn, Kendrick, and Deanna

ABSTRACT

The purpose of this study was to describe the current implementation of microcomputers in science education in the local district. The intent was to provide insight regarding the state of the implementation, the determinants which are having an effect on the progress of the implementation, and some probable directions of future activity.

The implementation process was examined through case study methodology, including two area-wide surveys over three school districts, school visits for directed and non-directed observation, and interviews with involved teachers and students. A concentering model for case research was developed and utilized in an attempt to provide both breadth and depth in the study process.

In the initial phase of the study telephone interview technique was used to provide a broad picture of the state of the implementation. A rapid expansion in microcomputer numbers and indications of extensive teacher involvement were indicated by the data. At the same time, science teacher involvement was found to be at a level consistent with a very early implementation stage.

Subsequent to this study phase seventeen schools were selected and directed observations and teacher interviews were conducted. This phase was intended to determine the reasons and the mechanisms through which science teachers had become involved in the microcomputer implementation, the present directions the teachers were pursuing, and their

expectations for the future. Five involvement mechanisms were identified, of which previous computer exposure or interest appeared most significant.

In examining the factors inhibiting the spread of the implementation the researcher identified three main areas of concern. Hardware availability and software availability and quality were the most significant of these. At the same time, five factors were identified which appeared to sustain and spread the implementation.

In a parallel phase of the study a number of student small-group interviews were used to obtain student perceptions of and responses to computer-based-education issues. Findings included high levels of interest and enjoyment, a sense of personal accomplishment in mastering the technology, and a generally positive overall attitude toward computers in the classroom.

The final phase of the study involved a detailed examination of six sites over a period of ten months. From this phase a series of descriptive case statements were drawn up as examples of the process and progress of the implementation. In addition, a "delphi-like" interaction with teachers was used to generate a set of position statements regarding the humanistic use of computers in the schools.

The overall findings of the study are presented in the context of prevalent models of implementation drawn from the literature. The findings with respect to this particular

implementation suggest some changes to current implementation models may be warranted.

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INTRODUCTION TO THE STUDY

> Do not, my friends, assume that the system will automatically ensure that this most vital of new technologies is put to good use. You must take the time to grasp it, to understand it, and to help decide how it will be wisely used to benefit us all.
>
> (John Madden, "Julia's Dilemma", 1980)

The structure of this report is as follows: this chapter introduces the study, describing the general nature of the study and giving an overview of method. Chapter 2 provides a review of the literature which constitutes the theoretical framework of the study. Chapter 3 details the research method. Chapter 4 describes the preliminary and follow-up survey phases of the study. Chapter 5 describes the preliminary site visits and poses some guiding questions for sucessive phases of the study. Chapter 6 deals with student perceptions of the computer and its use in the classroom. Chapter 7 discusses the detailed site visits which provided descriptions of a series of parallel cases involving six area schools. Chapter 8 summarizes the findings of the study and proposes some further research.

1.1 Background to the Study

It is just forty years since COLOSSUS, now believed to have been the first electronic digital computer (Mocciola, 1980), was powered up to assist the British war effort[1].

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[1]. ENIAC, built in the laboratories of the University of Pennsylvania. and put into operation in 1945, was, until recently, believed to have been the first fully electronic computer.

These devices, deliberately fashioned to replicate logic operations in a manner similar to the manner in which such operations would be carried out by human clerics, represented a technology quite unlike any industrial technology which preceded it. In the years since that historic occasion, computers have revolutionized activity in science, business and industry. Today they are a pervasive part of our everyday lives.

As early as the late 1950's, educators working at Stanford, Florida-State, and Dartmouth, began applying computers to the tasks of instruction. (Chambers and Sprecher, 1980). Following extensive experimental work through the 1960's, many predicted widespread adoption of the devices for education. It was further assumed that the impacts on classroom practice would be substantial. Others maintained that implementation on a large scale was unlikely to occur rapidly, if ever. Oettinger and Marks (1968), for example, suggested that systems amenable to the introduction of technology are characterized by considerable independence from other systems, well developed research tools, and clearly specified and specifiable goals. These are not characteristics typical of the school system, in their opinion. In addition to characteristics of the system, Oettinger and Marks also identified teacher resistance and hardware reliability as probable trouble areas. Optimism continued to run high among the proponents and developers of the technology. Bell Canada, for example, carried out a

study using the Delphi technique (Doyle and Goodwill, 1971), which predicted widespread adoption of computer assisted instruction in secondary schools by the late 1970's. Such adoption did not occur. Godfrey (1980) suggests two reasons for the failure of the educational revolution the Delphi predicted. One was the resistance of the teaching establishment, and the other was the tendency of early adherents to become caught up in the "fascinating techniques" (i.e. technically interesting aspects of the hardware and software) while failing to pose deeper educational and philosophical questions which may be raised by the use of this technology.

Yet substantial numbers of computing devices are appearing in the schools. The rate of acquistion is also accelerating. Petruk (1981) reported on microcomputers in Alberta schools as of December 31, 1980. He found 256 microcomputers in use in close to 12% of all Alberta schools. These numbers have increased rapidly,[2] with government support. Similar programs are underway in other provinces. British Columbia has carried out a pilot project (Forman, 1981) and is proceeding toward wide scale implementation. Ontario has gone as far as drawing up specifications for an "educational" microcomputer and a

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[2] The Honourable Dave King, Minister of Education for the Province of Alberta, speaking at the Alberta Society for Computers in Education conference on October 23, 1981, stated that the expectation of his department was that the approximately 1000 microcomputers currently in the schools of the province would triple by the Spring of 1983. He further suggested that this growth would be encouraged and assisted by his department.

consortium of Ontario companies has been formed to build this specific product.

Such a rapidly accelerating pace of acquisition is rather alarming, given our rather limited knowledge of the potential impacts of wide scale classroom use. The timing of this adoption appears to be driven as much by economic, social, and political factors as by any perceived need for the technology on the part of teachers as a whole. There are many forces which might effect the adoption of a complex technology in a complex social system. The initial directions in which such an implementation moves may largely determine the final outcome[3]. For this reason it seems appropriate to study this particular change process at an early stage in its development. We should heed Madden's (1980) warning. As he suggests, we cannot assume the system will ensure that computers are put to good use. It would seem of critical importance that we examine this

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[3] Maruyama's (1963) notion of mutual causality is possibly applicable here. By mutual causality is understood a process by which various parts of a complex system influence each other. Thus, rather than a one-way causal model, where a change in 'x' brings about a change in 'y', the mutual causal model implies that a change in 'x' may bring about a change in 'y', which then results in a further change in 'x'. This can be modelled as a "loop". Such mutual causal loops can, in Maruyama's terminology, be either "deviation counteracting" or "deviation amplifying". Change processes, of which technology implementation is an example, might be expected to exhibit causal loops which tend to increase diversity and change, that is, amplify deviations, and causal loops which tend to preserve the status quo, that is counteract deviation. Maruyama's treatment of deviation amplifying mutual causal process proposes that the initial directions of activity may have a substantial bearing on the development and direction of a change process such as the adoption of a technology.

implementation very closely, in an attempt to obtain a wholistic understanding of the process. Only through such understanding will educators be in a position to influence the continued development of the enterprise. It seems very likely that the computer will be widely used. Whether this use will be "wise" use is unclear. The "window" for successful intervention may be small.

1.2 Statement of the Problem

The implementation of computing devices as an integral part of the curriculum in schools is problematic in a number of ways. First, we have little knowledge of the effect the technology might have on the role of the teacher or of the student. Computer systems intended to carry out instruction may be viewed as threatening to teachers. Even systems clearly designed to assist teachers to carry on instruction may substantially alter teacher roles. When caught up in the technology, it is easy for researchers to ignore this issue. Baker (1971), for example, reviewed six major computer-based instructional management systems, and noted that none of the published reports explained how teachers made use of the reporting functions of the systems or presented any evidence of a more effective role for the teacher.

Even given a clearer idea of teacher role in the presence of the technology, retraining and reorientation of teachers may be required. Bent, Liebowitz, and Krawec (1980) have commented on the magnitude of a French government

project which will install 10,000 microcomputers in the public school system and involve the training or retraining of 10,000 teachers to work with the machines in the classroom. Dennis (1978) has specifically addressed the question of instructional applications of computers in the classroom. He suggests that the level of proficiency necessary to adapt the computer to the instructional process is difficult to attain with on-the-job inservice training. He advocates a much expanded pre-service program of instructional computing literacy. In the absence of a wholistic view of the local implementation, it is difficult to even propose an appropriate course of training, at either the pre-service or the inservice level.

This stems, in part, from widely differing perceptions as to the appropriate role for the devices in the classroom. Bent (1981), reporting on a major international conference on computers in education held in Lausanne, Switzerland, noted:

> "It's clear, even in this select group, that 'computer literacy' is badly needed. For example, I doubt that many attendees yet understand the important differences among training in computing science and technology, the use of computers as an instructional medium (CAI), and the use of computers as a tool to manage education (CMI). It is also apparent that many workers in this field are either ignoring the experience of others or failing to use established techniques, such as statistical analysis or theories of instructional methods. For some, any use of the computer for education qualifies as computer assisted instruction .... Come to think of it, as a group the conference attendees seemed to represent the same generic types found right here, in our very own Province of Alberta." (p. 7)

On another occasion, Bent (1980) raised as an issue that

many practioners are "reinventing the wheel ... because of a lack of an overall plan, guidelines, and comprehensive information regarding the use of computers in education ...." (p. 18).

Such broadly based concerns might be expected to also apply at the discipline level. Computers may be applied differently in different discipline areas. A recent task force study reported by Chambers and Bork (1980) noted the two discipline areas of mathematics and science[4] as the heaviest users of "computer assisted learning" in United States secondary schools. The present study will focus on the use of the microcomputer in science education, since it seems likely that a wide diversity of applications will be found in this discipline area. At the same time, it is unclear how such use in science will be viewed within the school as a whole. If 'computer literacy' is not widespead, as has been implied by Bent (1981), a collegial supportive atmosphere could be difficult to attain within the school. It would be regretable, in the opinion of this researcher,

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[4] Use of these techniques in science education have a considerable history. Kotak and Goddard's 1966 paper reports use of a classroom computer in grade 12 physics to increase computational efficiency and extend the range of observations in a laboratory on the pendulum. Bork's 1968 paper reports uses in physics instruction including tutorial instruction, computational assistance, and some fairly simple simulation activities. Bork (1976) describes some much more elaborate simulation and tutorial work done at the University of Calfornia at Irvine. Work in chemistry done by Stan Smith on the PLATO system at the Univesity of Illinois is illustrative of some potentials. Sugarman (1978) has described some of Smith's work, as well as that of Bork. The Open University of Great Britain also reports use of tutorial and simulation packages in science education (Bramer, 1980) in a distance education environment.

if the use of microcomputers tended to widen the gulf between the sciences and humanities, in the minds of either teachers or students.

A fourth area of concern is the potential impact of computer use on the curriculum. Teacher mediated instruction produces a curriculum in practice which may deviate to a greater or lesser extent from the curriculum as designed. In some instances teachers may be given considerable freedom in structuring curriculum. Regardless of one's philosophical position on the desirability of such practice, it is possible that extensive classroom computer use could alter this historic relationship. The packaging of substantial amounts of curricular content in computer form could result in a rigidity which would lessen teacher control over content decisions. Furthermore, the nature of computer activity could alter perceptions of disciplines through change of emphasis. Extensive use of simulations over hands-on laboratory experience could occur, for example, altering the emphasis on psycho-motor skills relative to cognitive understanding.

Finally, impact on curriculum and on teacher role might be expected to be greatly affected by the pattern of computer use which emerges. There are alternate conceptions of the most appropriate ways to use these devices, often reflecting a particular view or philosophy of education. Frenzel (1980) appears to view the greatest potential as that of "computer assisted instruction". In this mode the

computer is used either to drill concepts, an automated worksheet with instant feedback, or to dispense new information, as a tutor. Large scale projects such as the Minnesota Educational Computing Consortium (MECC, 1980), have been set up to produce and/or disseminate instructional programming. In the British Columbia project reported by Forman, utilization for computer assisted instruction was stated as the prime objective of government in initiating the project. Travers (1981), in developing a model for implementation in Alberta schools, clearly recognizes wider possibilities but thought it advisable, in his study, to restrict activity to drill and practice because of the programming difficulties likely to be encountered by teachers.

Others have viewed the computer as capable of providing a richer resource for classroom experience (Kotak and Goddard, 1966; Bork, 1968; 1976; Papert, 1972; Lipson, 1979; Dwyer, 1980; Thompson, 1980; Abell, 1981). Luehrmann (1980), in assessing the role of technology in science education, has remarked on the "uses of 'appropriate technology'" which have progressed "without much publicity or systematic support". He sees the computer as "... an aid in understanding a wide variety of traditional subjects". He suggests the use of the computer to solve problems, search for data, and to create simulations and models. Whether such uses are likely to become prevalent is unclear, however. The perceptions and experiences of teachers and students,

together with pressures from within and without the schools, can be expected to shape these activities in a substantial way.

The focus of interest in this study will be in the classroom implementation of the microcomputer in secondary science education. As has been indicated previously, natural sciences have been the area of second highest utilization of computer assisted learning in the United States (Chambers and Bork, 1980). A large variety of possible usage models should, therefore, be available. In addition, by the secondary level, students should have developed considerable skill in manipulating formal knowledge and reasonably complex physical mechanisms. From the curriculum point of view, topics of study are dealt with in a manner requiring considerable cognitive complexity. This, in turn, implies a breadth of teaching and learning activities which could, in theory, involve computer use.

1.2.1 The Purpose of the Study

The purpose of the study is to contribute to our understanding of the dynamics involved in the current implementation of microcomputers in the classroom. This suggests an interest both in describing the current local situation as it exists, and in determining the teacher-student-machine-environment interactions which may be actively shaping the direction of implementation. The area of specific study is applications in science education

at the junior and senior high school level.

1.2.2 Major Questions Addressed by the Study

In describing the implementation an attempt will be made to answer the following questions:

1. How far has the implementation progressed in secondary science education?
2. Who are the participants in the implementation process and what roles do they play?
3. What appear to be the major determinants of implementation at this stage in the process?
4. What directions would seem most appropriate in furthering the progress of the implementation?

These empirical questions provide the content and setting through which the following theoretical question is addressed:

5. Is this particular implementation adequately described within the confines of the major implementation models proposed in the literature?

1.2.2.1 Some Questions of Interest

In approaching "in situ" research, the researcher must endeavour to be open to the possibility of many influences which cannot be forseen. At the same time, certain broad areas were prejudged to be likely areas of interest. In this study, the teachers and students are the chief actors in the implementation. As such, their perceptions, in terms of knowlege, attitude, bias, and

understanding, both of the technology per se, and its effect on the educational praxis, were assumed of considerable importance. The following questions may serve to give some "flavour" of these areas of interest:

1. How do teachers' perceptions of the computer influence their utilization (or non-utilization) approach?
2. Is there an apparent relationship between teachers' educational philosophy and their approach to computer use? Is this impacted by environmental factors (government, administration, students, curriculum)?
3. Do teachers and/or students perceive shifts in role or in classroom atmosphere as a consequence of the introduction of microcomputers? If so, what is the nature of these shifts, and how do these influence the curriculum in practice.
4. Do teachers' perceptions of the computer in education undergo change on the basis of short term exposure to this medium in the classroom? If so, in what ways do they change?
5. Do teachers' perceptions of the curriculum in practice change on the basis of short term use of this medium? Do aspects of the discipline take on new importance? Does their understanding of the nature of the discipline appear to change?
6. Do teachers perceive long term (five to twenty-five

years) curriculum effects through use of computers, either in the nature of the prescribed curriculum or in the curriculum as implemented? If so, do they feel the effects will be positive or negative? Do teachers feel any sense of control over these effects?

1.2.3 Description of the Research Method

This study attempts, through a naturalistic case study approach, to describe the implementation of microcomputers in science education at the secondary school level. Within the stated delimitations of discipline and grade level, the study attempts as broad a description of the implementation as possible. According to Lincoln and Guba (1981), the naturalistic methodology assumes that the nature of truth statements about complex social/behavioral phenomena are context bound. These authors suggest that such phenomena can best be approached through "thick description". They further describe the qualitative method as "especially well suited to studying 'instances in action'". There is a tendency to characterize case study method by "what it is not". This may derive from a methodological debate between schools of educational researchers which is now in its second decade, as to the appropriateness and truth claims of their respective methods. It appears, to this researcher, to be unproductive to enter into this debate. Rather, in the context of the study of a complex dynamic process, it seems

appropriate to judge the value of the methodology primarily on pragmatic grounds.

For the purpose of this study, the method is described as an observational approach which attempts to include within its purview any potentially relevant factors which may affect the progress or directions of the phenomena under study. This was interpreted to mean that the research method should remain open to changes in observational procedure, participants, and venue, where such changes appeared appropriate on the basis of working hypotheses developed "in situ". The direction is toward the development of "grounded theory" (Glaser and Strauss, 1967; Smith and Pohland, 1974) having potential pragmatic value.

The methods which were employed are dealt with in some detail in chapter 3. Presented here is a brief overview. Four school districts in the greater Edmonton area were contacted and a list of schools drawn up where teachers were involved at some level in implementing microcomputers. Initial data on the extent of the implementation was obtained by a telephone survey of principals in forty-seven area schools. From this information and through discussions with board personnel, the list of schools was refined to seventeen schools over three jurisdictions. The main criterion for this refinement was the identification of science activity in the school. Interviews were held in each of these seventeen schools with the teacher and/or in some cases the principal involved. Some additional descriptive

data on the sites was obtained by direct observation. The outcomes of this phase of the study are described in some detail in chapter 5.

Following this preliminary investigation, six sites were selected from the seventeen, using criteria intended to achieve a broad view of implementation factors. These criteria included: a range of times from zero to four years during which microcomputers had been available at the site; a range of grade levels from grade eight through grade twelve; a range of science subject areas; a range of sites identified as experiencing particular success or difficulty. The six schools were included in a case study to identify key elements and activities which have been influencing this implementation. Techniques which were employed in carrying out the case studies included directed and non-directed observation, interview, document analysis, and dialogue. A more detailed description of the research method is included in chapter 3.

A second activity involved the identification of teachers who appeared, on the basis of the initial phase of the study, to have given some serious thought to long term implications of the adoption or non-adoption of computer technology in the schools. These teachers then participated in a "Delphi-like" process intended to develop a model or models of a humanistic educational environment employing computers. The procedure is described in greater detail in chapter 3.

The telephone survey of forty-seven area schools was repeated toward the end of the study in order to generate some comparative change data.

1.3 Definition of Terms

The use of terminology within a complex applied field like education presents problems in that many terms are adopted from other fields, and all terms have meaning only in the context of personal experience. Topics such as "curriculum" and "implementation" have been the subject of lengthy discourse in the literature. It is precisely because there can be considerable disagreement on the meaning of such terms that they are included in a "definition of terms". As such, the author does not propose these as "universal" definitions, but rather as presenting the sense in which he is using the words. In so doing, one undertakes to try to be as internally consistent as possible.

Case Study Method - an observational approach which attempts to include within its purview any potentially relevant factors which may affect the progress or directions of the phenomena under study.

CAL (Computer Aided Learning) - a method of using a computer such that a student dicovers information or concepts through activities such as computer simulation or through programming of his own algorithms.

CAI (Computer Assisted Instruction) - a method of teaching in which the computer either drills concepts

previously presented by other means, or presents new information interactively based on a predetermined instructional logic featuring a limited number of alternative routes.

CMI (Computer Managed Instruction) - a procedure in which records pertaining to student performance. are maintained on a computer and the data therein used for purposes of prescribing, under some degree of computer control, appropriate additional learning activities.

Computer - an electronic device which processes symbols in the form of electronic pulses, and is capable of modifying its processing on the basis of information contained within the symbols themselves. Usually used in the sense of "general purpose" computer - i.e. capable of handling a wide variety of different kinds of symbol processing tasks.

Contextual Effect - an effect on a variable under study which results or may result from interactions with the complex interrelated conditions pertaining in the study environment.

Courseware - sequences of instructions to a computer which allow it to carry out instruction, generally of the drill and practice, or the tutorial type. Implicit in this definition, is the inclusion of the "content" of the instruction within courseware.

Curriculum - all of the activities and outcomes, intended or otherwise, which can be associated with an

educational environment.

<u>Impact</u> - to make forceful contact; x is said to impact y if changes occur in y in the presence of x which are not observed in the absence of x. This does not imply a simplistic assumption of unidirectional causality of the form "x causes y".

<u>Implementation</u> - the act of providing means for the practical expression or fulfillment of intents by concrete measures; a dynamic process in which methods, procedures, and/or content become a part of classroom practice.

<u>Innovation</u> - a deviation from established doctrine or practice based on combining educational variables in new ways. It should be noted that what is innovative in one setting may not be in another, since it must be related to the practice in the setting as it existed prior to the innovation.

<u>Simulation</u> - the representation of a system in terms of a model which imitates the system in some respects and which can be manipulated such that relations between variables in the model can be discovered.

<u>Software</u> - any set of symbolic instructions to a computer which the computer can directly use to control its operation. Often used in referring to courseware, where the more specific term is preferred.

1.4 Delimitations of the Study

The study examined the current implementation at a number of levels, beginning at the metropolitan school districts level and focussing through preliminary surveys and contacts down to the detailed site visits of six area schools. Consistent with the overall research plan and given the restrictions on both time and resources, the following constraints were applied:

1. The general survey was restricted to forty-seven schools within three jurisdictions, which were polled on two occasions by telephone. This was deemed appropriate procedure given the nature of the questions to be asked. A written questionaire or site visit at this level would have contributed little additional information. Furthermore, the telephone procedure guaranteed one-hundred percent response at a clearly identifiable point in time.
2. Seventeen schools participated in the preliminary site visits. One or two science teachers from each school were involved in the initial interviews. These were teachers specifically identified by the principal as involved in the implementation, and as such were judged to be in a position to provide the overall description of science/computer activity required at this level of the investigatiion.
3. Detailed site visits involved six schools in total over the three jurisdictions. This was seen as an appropriate

compromise between the requirement to maintain a broad view of the implementation and, at the same time, provide a more intensive examination of specific cases. Criteria for the selection of the six sites are presented in chapter 3.

4. At the detailed site visit level, no mechanism to exclude contextual effects was used in data collection. Rather, an attempt was made to fully describe contextual determinants.
5. At the level of the overall study, time and resource restrictions dictated the following additional delimitations:
   a. The overall study was restricted primarily to the area of secondary science education.
   b. The overall study was restricted to three school jurisdictions within the Greater Edmonton area.
   c. The study was limited to fifteen months between December 1981 and February 1983.

1.5 Limitations of the Study

1. The schools participating in this study were not chosen randomly. The purpose of the study is to contribute to an understanding of the implementation process rather than to attempt to estimate population parameters. The reader must be the judge of the relevance of the findings in other settings.
2. Decisions were made in site selection and in levels of

data sought which ruled out all possible combinations of potentially interesting variables. Interactions involving combinations which were not observed might have led to different outcomes.

3. The study was of limited duration and represents the situation in the study schools for the fifteen month period ending in February, 1983. Since the implementation of microcomputers in science education is undergoing rapid change, the usefulness of the specific study data may be limited both over time and as a consequence of changes in policy and in school setting.

1.6 Assumptions of the Study

1. The research assumes the suitability of Maruyama's (1963) notion of deviation amplification for the description of change processes and thus the appropriateness of carrying out a study of implementation at a very early stage in the process.
2. The study assumes that the chosen informants have sufficient "breadth of perspective" to provide stable responses to the questions presented to them. While there is, of course, a personal element in their verbal descriptions, it is assumed that their interpretations are governed by standards of judgement shared by other teachers at the same level. As the active implementors, they are assumed to have sufficient experience to provide a consistent view of the process under study.

3. The study methods assume for the most part that the respondents are direct and open in replying to questions. At the same time, some attempts were made to triangulate the data wherever possible.

1.7 Significance of the Study

The picture developed through this research has the potential to enhance our understanding of the implementation process of a state-of-the-art educational technology through clarification of participant roles and identification of possible 'causal loops' in the system. Secondarily, it may inform policy making at all levels of administration and government, and particularly in organizations having responsibility for teacher education.

Chapter 2

REVIEW OF RELATED LITERATURE

The world view of the researcher is both the source of problems, which, from his perspective, are worthy of research, and at the same time an influence on his perceptions of the meaning of his lived experiences as a researcher. In the context of the present study, this suggests a review of the literature in those areas which intersect, in a substantial way, with the dimensions of the problem as perceived, and, at the same time, a review which develops in the manner of argument, the world view that makes the research a question of interest. One hopes, in the process, to lead the reader to an understanding, to a way of thinking about the problem, which is more than a disjointed analytical view but rather blends the disparate lines of thought into a perceptual whole.

2.1 The Structure of the Review

In the preceding chapter, it was proposed that extensive use of the computer for education and training would occur within the next decade. It was further stated that such use has the potential to fundamentally alter the process of education. These propositions will be developed in the following ways. First, a view of curriculum as a meeting ground between conceptions of education on the one hand, and the operant factors of implementation of these conceptions on the other will be developed.

Second, the development of computer based education will be discussed. In this section, three leading interests will be differentiated and an attempt made to show how they have shaped perceptions of the problem.

Third, the technological developments which have occurred will be described and ways indicated in which these developments represent socio-politico-cultural determinents of future directions. This will, of necessity, require a consideration of the essence of technology and its relation to education.

Having thus established the ground in which this study takes shape, the following chapter will develop the methodology by which one hopes to enhance understanding of the problem.

2.2 Curriculum, Implementation, and Innovation

For this researcher, the notion of curriculum is broadly interpreted to be all of the activities and outcomes, intended or otherwise, which can be associated with an educational environment. As such, organization, structure, and technology are inextricably bound to intentions, activities, and outcomes. The notion of curriculum as a set of content specifications which defines practice is rejected. Some curriculum development activities through the 1960's and 1970's recognized this in part. Attempts were made, through workshops, to prepare teachers for new teaching activities, not only in terms of their

conceptual understanding of the subject matter, but also in their approach to the discipline as a whole. The author was an instructor in such a workshop held at the University of New Brunswick in the summer of 1967. During this workshop an attempt was made to develop, in the trainees, a wholistic view of their teaching activity. The organization of the laboratory sessions, for example, was seen as a way of developing, in the students, a degree of critical mindedness and a co-operative approach to problem solving which was implicitly but not explicitly a part of the intended curriculum. An understanding of science as something scientists do rather than as a body of factual knowledge was an implicit part of many of the programs developed at this time.

Yet in the day to day activities of any individual teacher and class, there is no guarantee that such an understanding will be developed, or that the conditions of learning will even favour such development. The organization and structure of the educational environment may lead to quite different outcomes. Students may conclude, for example, that science is far too difficult for them, or girls may conclude that it is a "male" area of study. Such conclusions are as much a consequence of the course of studies and its execution as are facts reflected by scores on an objective test. Curriculum thus becomes the lived daily experience of teacher and student, which may have little in common with the expectations of curriculum writers

or curriculum theorists. As Roberts (1975) has pointed out, the teacher is faced with choices in real environments, affecting the lives of real people. These are, of necessity, ethical decisions which may bear little relationship to research theories developed in other contexts. It is only in context that one can make sense of the myriad intuitive and formal decisions which are the daily life of the teacher. Teachers, then, become central to the question of curriculum in practice, and hence central to any understanding of implementation or innovation, for it is through their understanding of themselves and of the contexts in which they engage in pedagogical acts that curriculum becomes practice.

2.2.1 Implementation as Changing Practice

From time to time an attempt is made to change the nature of practice in the school. This may involve changes in content, organization, and/or structure directed toward changing educational outcomes. The most common usage of the term implementation, with respect to educational environments, involves implementation of a new course of studies - i.e. the specification of a new body of content which is to be taught in the schools. To the extent that such a course of studies calls for new practice on the part of the teacher and the learner such implementation may be described as innovative.

It is important to note that such a definition of "innovative" is a relative rather than an absolute definition. Many "innovative" teaching methods, for example, are not in any absolute sense "new". Individualized instruction, for example, certainly pre-dates recorded history. Its large scale introduction into the modern school, however, would be considered innovative, since it would result in changing practice.

This dissertation is specifically concerned not with implementation per se, but with implementation of an innovation. House (1979) defines education innovation as "the deliberate and systematic attempt to change the schools through introducing new ideas and techniques." Fullan and Pomfret (1977) describe implementation as "the actual use of an innovation, or what an innovation consists of in practice". (p. 336). This is an "after-the-fact" definition which does not adequately view implementation as process. In the context of innovation, the author views implementation as a process by which change in practice occurs.

2.2.2 Implementation as Process

In describing a study of 239 innovative projects in education, McLaughlin (1976) distinquished three different interactions: mutual adaptation, involving changes in the design as well as the setting and participants; cooptation, where the project stratagies were modified to conform to the traditional practices; and nonimplementation, where projects

broke down or were ignored by participants. Since the microcomputer implementation does not appear to be characterized by well ennunciated goals and aspirations, but rather by various perceptions of possibilities for action, mutual adaptation (McLaughlin, 1976), in which the project "design" as well as the setting and participants undergo change, may be expected to occur. In pursuing this study an attempt will be made to characterize various activities in terms of these three different interactions. It is important to note, however, that McLaughlin appears to be describing a case where the original goals of the implementation are clearly specified. An implemention lacking stong goal direction at the central agency level might be expected to exhibit great diversity in direction, as well as high susceptability to changes in direction through idiosyncratic behaviors and events.

2.2.3 Implementation as Problematic

The notion of implementation which has been prevalent in education over the past three decades appears to reflect an instrumentalist outlook which McLaughlin (1976) has described as "the direct and straightforward application of an educational technology or plan". He describes implementation rather as a "dynamic organizational process ... neither automatic nor certain" (p. 340).

Fullan and Pomfret (1977), in a review of fifteen implementation studies, note that one important reason to

examine implementation is to understand why many educational changes do not come about as planned.

Guba and Clark (1975) described as a "cycle of failure" attempts to produce change in educational practice. They have identified a lack of congruence between the goals and aspirations of centralized change advocates and the realities of the "real world of educational KPU" [knowledge production and utilization] as a principal factor in this failure.

It is clear that the notion of a "failure" in implementation reflects a position that products (eg. learning and organizational theories, curricula, mechanisms) generated by research and/or scholarly activity should be directly transportable to classroom practice. But low levels of implementation appear to have been the frequent outcome of some major efforts to effect curricular change in the schools. Welch (1979) reviewed twenty years of science curriculum work, including all of the major "alphabet" curricular efforts supported by the National Science Foundation. He concluded that "... the educational system is extremely stable, and efforts to change it have little effect". This finding is in concert with the position stated by Oettinger and Marks(1968) on implementation of educational technology, in particular computer technology in the schools.

2.2.4 Models of Implementation

In attempting to determine the nature of implementation, many models have been proposed. House (1979), in his ten year review of educational innovation, notes that three overall perspectives have emerged. He identifies these perspectives as the technological, the political, and the cultural.

In choosing the term technological, there is an implicit and explicit connection to a control paradigm, which assumes a clearly identified goal. How the goal is identified in this paradigm is frequently unclear. One view is of a scientific (or political) elite who provide "answers" in terms of research which are then developed and diffused to passive "consumers". As House (1979) points out, this reflects an "industrially oriented technology".

There is a tendency to equate such perspectives with the so called "systems approach". True systems analytic models appear to have been largely overlooked in the implementation literature, however. A "whole systems" approach to the study of implementation precludes as a choice the separation of goal from mechanism and purpose from politics. There is, however, a frequent lack of understanding concerning just what a "system" is. Guba and Clark (1975), for example, talk about a "unified-system view" of educational knowledge and production. Clearly they are not talking about a system in the Bertalanffy (1968) sense of the word. This is evident in the following quotes:

> "... a system could be engineered in which component agents and agencies had defined roles linked together in such a way that the output of one component agency ... would become the input for the next agency ....
>
> "Such a unified system would ... have shared goals which could be achieved by insuring productive output at the adoption end of the RDDA continuum. " (Guba and Clark, 1975, p. 7)

It should be noted, lest the reader infer that Guba and Clark support this notion, that this is not the substance of their position:

> " ... it is extremely difficult to demonstrate that 'the system' is producing what it purported would be produced, i.e. a consistent flow of inventions being adopted by schools as solutions to their operating problems." (Guba and Clark, 1975, p. 7)

This example has been used to illustrate the point because it is, in the opinion of this author, typical of the perception of a "systems approach" which in fact is simply a statement of the standard industrial model to which House (1979) has referred.

The key issue is that in general systems theory a "system" is not "engineered" or created in any industrial sense. A system exists as a teleological entity. Such a system may be describable more or less precisely by a model. The model is only a representation of reality, not to be confused with any absolute notion of reality as fact. Multiple perspectives serve to create different models of reality. Thus, a technical control model assumes the existence of a set of definable procedures (or means) capable of attaining, in a non-problematical fashion,

predifined outcomes (or ends). In such a model, both the means and the ends are essentially viewed as external to the model and only serving as inputs to it.

A political model deemphasizes mechanistic aspects of the system, and focuses instead on the nature of personal relationships and power structures within the system. Persons involved in the implementation process are viewed as goal-directed, but the goals involved may have little to do with the goals of the implementation.

House (1974) states:

> "In analyzing the school and the school district I intentionally neglected most considerations of the content of the proposed innovations and their consequences for children in order to emphasize the political and social dynamics of the system." (House, 1974, p. 301)

House (1974) has dealt fairly extensively with the issue of benefits which accrue within the institutional and social hierarchy as a consequence of innovative activity in the school. The fact that the "rational self-interests" of participants in the current implementation are far from being clearly defined at this point, and that the placing of powerful technological devices within the schools has the potential to threaten bureaucratic control mechanisms or to enhance them, adds a measure of complexity to the innovation under study which makes the process of particular interest. The political and social dynamics might be expected to represent an extremely important aspect of the total picture developed by this study.

McLaughlin has commented on the particular influence exerted by central administation attitudes and interest on prospects for successful project implementation.

> "Unless participants perceived that change-agent projects represented a school and district educational priority, teachers were often unwilling to put in the extra time and emotional investment necessary for successful implementation." (p. 341).

This certainly is an issue of importance in the current study, even though, as has been previously mentioned, the initial push for microcomputer use may not have been centrally derived. Central agency support, or at least acquiescence, is a major factor in sustaining innovative activity.

The cultural model appears to concern itself with role relations of participants within a system involved in implementation. Rather than focusing on individuals' goals unrelated to the goals of the implementation, as does the political perspective, the concern is with establishing, between a research culture and a professional culture, shared goals and values which are appropriate to the innovation (House, 1979).

When stated in these terms, the cultural model appears inappropriate in the current situation, since the model implicitly assumes a research culture providing leadership for the professional culture. Such a separation of functions may not be occurring in the current situation. Rather, there seems the possibility of a rapid expansion of "research like" activity in the professional ranks, with little formal

contact with previous researchers in the field. Networking within the professional culture, however, may be of major importance in the progress of the implementation.

All of the models described in this section implicitly or explicitly assume that the source of the innovation is located organizationally above the rank of the classroom teacher, who must ultimately accept, adapt or reject the implementation. In chapter 8 an attempt is made to describe the current implemention in terms of a more general model, which incorporates aspects of the technological, the political, and the cultural perspectives identified by House (1979).

2.3 Qualitative Method in the Study of Implementation

For the purposes of this study, the case methodology has been selected as an appropriate tool for the study and description of a complex phenomenon. It is necessary to consider, however, the possible threats to validity and reliability which attend this methodology. These issues will be discussed in the following sections.

2.3.1 Validity and Reliability Issues in Case Study Methodology

In attempting to assess the quality of social science research, questions of validity and reliability are of paramount importance. In determining their importance and interpretation in case study methodology, one must reflect

on their meaning in the experimental design paradigm which has largely dominated educational research thinking, at least since the 1963 publication of Campbell and Stanley's "Experimental and Quasi-Experimental Designs for Research on Teaching".

Validity is clearly the dominant consideration. Reliablity is an issue in validity, generally referring to the accuracy or consistency of results of measurement operations or to the accuracy of statistical inference as a consequence of sampling errors (Nelson, Denny, Colardarci, 1956, p. 142, p. 167). In the context of obserational systems, Herbert and Attridge (1975) state:

> "Reliability refers to the consistency of the instrument as a measuring device, its tendency to obtain the same results from similar events even though these events are separated in time or location, or have different participants or settings."

Explicit in this statement is the emphasis on "sameness" or "consistency", "even though" participants and settings vary. Implied in this statement is the link between reliability and the desire to generalize findings to other settings and participants. The link between reliability and validity in qualitative research paradigms is more tenuous.

Perhaps because the term "reliability" is strongly associated with the measurement paradigm, most authors dealing with the epistemology of case study research organize their discussion around the topic of validity. This strategy will be followed while at the same time questions of reliability will be noted along the way.

Dawson (1979) has conceptualized validity as "the adequacy of a description as a representation of a social situation" (p.1). In so doing, she has pointed out that this definition implies that a purpose or utility is associated with the concept of validity. It is worth noting that "valid" and "value" both derive from the Latin "valere", to be strong. Reflecting on the meaning of valid in relation to value, one faces a dilemma. We tend, in our scientific stance, to view validity as a pre-cursor to value. In order to be of value, results of research must be predetermined to be valid. Such a stance can be associated with an absolute notion of truth. An alternative notion would be that validity is dependent on value - that valid knowledge is that knowledge which is shown to be of value. This is consistent with Dawson's (1979) notion of validity as being similar to utility. As Dawson infers, this view of validity removes the term from the realm of the strictly quantifiable, since validity may change as a function of use. Such a notion represents a substantially different epistomology than formist or mechanist views of the world, (Roberts, 1982; attributed to Pepper, 1942) which tend toward an absolute notion of truth.

One approach to resolving the problem of different epistemologies is to suggest that case study method cannot be judged or even discussed in the same terms associated with more traditional educational research practices. Such an approach, however, tends to create a schism between

practitioners which Reichart and Cook (1979) suggest is far from desirable.

The other approach is to adapt and modify concepts in going from one paradigm to another. In this way one hopes to build up a set of defensible procedures and "widely accepted warrants" (.Roberts, 1982) by which to move from data to conclusion. As Roberts (1982) has pointed out, such "warrants" are well established for formist argument, but,

> "...it is easy to forget that someone had to establish them and whole generations of researchers have had to come to trust them, share the metaphysical presuppositions behind them, and learn how to use them in making arguments based on data" (p. 290).

In this analysis, then, an attempt will made to relate the concept of validity and reliability to constructs drawn from "traditional" educational research, that is, research which is predominently formist and/or mechanist in terms of its metaphysical assumptions and which is experimental or quasi-experimental in its method.

2.3.2 Internal and External Validity

In their 1963 treatise on these subjects, Campbell and Stanley differentiated between the concepts of internal and external validity. External validity is associated with the generalizability of an experiment. Internal validity is concerned with whether, in fact, an experimental effect was observed or as Dawson (1979) phrased it "internal validity refers to the correct attribution of causality". In this classification, reliability issues are clearly a factor in

internal validity.

Brach and Glass (1968) extended the notion of external validity by subdividing it into "population validity" and "ecological validity". Snow (1974) added to these notions something he called referent generality, "...used...to designate the range or pervasiveness of possible experimental outcomes measured in a given study". In examining the issues of validity and reliability in case study, these concepts drawn from experimental science will be utilized.

2.3.3 Internal Validity Issues in Case Study

In considering the internal validity of the case study, the following questions may be posed:

1. Does a case study generate data?
2. Does this "data" have a claim to reliability?
3. What conditions enhance our faith in the reliability of the data?
4. If the data are used to attribute causality or theoretic relationships, what about the multiple-R problem. Can it be controlled?

In "traditional" educational research, data are usually associated with numerical results of measurement operations - test scores, frequency counts, and the like. Once reduced to numerical form, it is easy to forget that such data are attempting to describe, in non-ambiguous ways, a particular construct.

Suppose that one were interested in the learning construct "achievement in science". While recognizing the possible limitations of the measuring instrument, most experimental scientists would consider scores on a teacher made test as "data". Most would probably accept a rank ordering of students from "best" to "worst", done by the teacher, as data.

If a case study researcher questions a number of students on a science concept and reports that, on the basis of recorded protocols, certain students or groups of students do not understand the concept (in the accepted way), surely this too is data worthy of consideration.

The real issue here is whether the case study data are more or less reliable than the quantitative data obtained by testing. There is no specific answer to this question. In traditional testing, one is continually faced with trade-offs. Consistency and reproducibility, free from any possibility of subject bias on the part of a marker, can be obtained and shown to have been obtained, by the use of standardized multiple-choice tests. In doing so, however, one accepts, either consciously or unconsciously, that scores obtained from such an instrument may not adequately measure complex understanding. An alternative approach is to utilize free response questions, and rely on the ability of an expert judge, or panel of judges, in assessing a score. Subjective bias then becomes an issue.

In case study work, some information may be obtained through standardized testing. There is no prohibition on such activities. In other instances, data may be obtained by guided observation, using a prepared checklist. In most cases, however, a substantial amount of data is generated by interview and protocol analysis. Clearly, the problem of reliability here parallels the "experimental" situation.

A number of techniques are typically used to "control" reliability problems in case study. One consideration is the skill level of the researcher. Campbell (1979) notes that narrative history in evaluation reports should employ "...professionally trained historians, anthropologists, and qualitative sociologists..." who, he infers, will employ "...the best qualitative methods..." (p. 52). Having had so much impact on the training of professional educational researchers, it is regrettable that he could not include them in his list of desirables.

The important point, however, is that our faith in the reliability of case study measures is certain to be affected by our subjective assessment of the capabilities of the researcher(s). A degree of objectivity will be obtained by the practice of reporting lengthy protocols verbatim in research reports. In this way, the report reader can, to an extent, form his own conclusions about the researcher's method and interpretation. There still remains the problem presented by selection - what the researcher has chosen to include as affirmation of his position, and what he has

omitted. This may be a problem rather akin to criticism of instrument choice in traditional research. The difference lies in the fact that in the latter case, the research community has a clearer idea as to what has been passed over.

In discussing the use of photographs in presenting evidence, Becker (1979) notes that one problem is that evidence can be deliberately faked. Certainly this possibility holds true for both quantitative and qualitative research data. The researcher's integrity is the only real check on this.

A number of strategies have been suggested to assist in enhancing internal validity in case study. Shatzman and Strauss (1973), among others, emphasize the importance of researcher-participant relations. Clearly a large measure of trust is required on both sides if communication is to be effective. Dawson (1976) has discussed a notion (attributed to Douglas, 1976) that a research approach might be used which assumes that people are evasive or dishonest. Dawson seems to imply that in this case the researcher tests information received against his own "most reliable ideas". This researcher leans toward the other end of the continuum, believing that trust should be the initial stance, although this in no way suggests multiple methods of confirmation should not be used. Rather, the objection is to the suggestion that the researcher's own perspective is the appropriate point of test. Even given trust in respondents'

information, triangulation, in which data bearing on an issue is gathered from multiple sources, is frequently used by case workers. Smith and Poland (1974), for example, used multiple methods of data gathering (observation, interviews, document assessment), multiple persons (pupils, teachers, administrators, others) and multiple situations (schools, instructional modes, subjects, etc.) in their study. The current study employs a similar strategy. Stake and Easley aimed at a range of methods, although they recount difficulties in preserving some features of their original design, primarily as a consequence of the reluctance of their observers to utilize certain more structured data gathering techniques (Stake and Easley, 1978, pp. 17-19).

The triangulation strategy appears to serve primarily as a check on data distortion derived from site participants, which might occur as a consequence of either evasion or their own misperceptions of events. It is less likely to be effective in removing any systematic bias resulting from the researcher's own views of the problem.

Some possible procedures to be used as a check on such biases would include reviewing interviews or report drafts with site personnel. This technique was a part of the Stake and Easley procedures, although it appears the purpose was as much an ethical issue regarding protecting anonymity and confidentiality as a check on the perceptions of the researcher. Campbell (1979) suggests the inclusion, perhaps as footnotes, of possible dissenting opinions of other

social scientists as a check on researcher ethnocentricity. In the current study it would seem appropriate to review the case reports with the participating teachers as a confirmation of the accuracy of the information and adequacy of the researcher's perceptions.

Even given a reasonable faith in the reliability of data collected and presented, can one make inferences from this data? In a "partial recanting" of his earlier position with respect to case study, Campbell (1979) raises the issue of perfect fit, that is, the ability to completely explain any single phenomena provided one has a sufficient number of variables with which to explain it. This is the traditional problem of linear regression, where entering a sufficient number of variables is guaranteed to result in 100% explanation. Furthermore, the nature of correlation is such that in such a situation quite unlikely variables might be shown to account for substantial amounts of variance.

The researcher is, of course, under obligation to employ a certain amount of theoretical decision making in selecting variables to be entered or attended to. He does this on the basis of acquaintance with the literature and issues in the field. The only real difference in this procedure between the quantitative and qualitative researcher is a temporal one. If one views the case study in Campbell and Stanley (1963) notation as partially represented by: X-0-X-0-X-0-X-0, which is in keeping with the observation-confirmation strategies of Glaser and

Strauss (1967), appropriate variables to consider are evaluated at each stage of an extended case study. In the "traditional" mode, such decisions occur between studies rather than during studies.

Campbell (1979) has viewed the problem of multiple predictors as partially offset by the tendency, in the case study setting, for theory generation to lead to multiple predictions or expectations, most of which must be confirmed for the theory to be retained:

> "In some sense, he has tested the theory with degrees of freedom coming from the multiple implications of any one theory." (p. 57)

Cast in a non-statistical framework, this is an argument that the requirement for internal consistency among a large group of potentially contradictory hypotheses serves as a check on careless inference.

2.3.4 External Validity Issues in Case Study

If we assume that it is possible to maintain an appropriate level of internal validity, is there not still a serious problem in generalizing the results of case study work?

In considering external validity, the main questions are:

1. Can we generalize from case study?
2. To what can we generalize?
3. What steps must we take to enhance our ability to generalize?

4. What consequences attend errors in our proof?

The problems associated with generalizing from the particular are not peculiar to case study. Campbell and Stanley (1963), pointed out that in fact, attempts to tightly control internal validity of experimental studies frequently lower the external validity. In discussing population validity, Snow (1974) described three steps in going from empirical data to inference:

1. generalization from the observed sample to the accessible population which was the source of the sample.
2. generalization from the accessible population to the target population
3. interpretation of the meaning of the generalization with respect to the substantive phenomena which is being studied

Assuming that sampling is carried out appropriately from the accessible population, step one is not particularly problematic. Snow notes, however, that both steps two and three are more difficult. He suggests that the interpretability of findings would be enhanced by a thorough description of the characteristics of the sample and the population from which they are drawn (i.e. the accessible population).

Such a detailed description of sample characteristics is in fact common in case study. In generalizing from case study, one relies on the case reader's ability to recognize

features of the case as similar to situations known to him (Easley, 1982). As Stake (1978) notes,

> "the situation is one in which there is a need for generalization about that particular case or generalization to a similar case rather than generalization to a population of cases. Then the demands for typicality and representativeness yield to needs for assurance that the target case is properly described. As readers recognize essential similarities to cases of interest to them, they establish the basis for naturalistic generalization." (p.7)

It is interesting in passing to note that case methodology places a larger burden on the reader. It is the reader, finally, who must decide, by means of contextual cues, the appropriateness of the case findings for his purposes.

In the case of ecological validity, one is concerned with "...the extent to which the habitats or situations compared in an experiment are repesentative..." (Snow, 1974, p. 272) of the universe of situations to which one wants to generalize. Again, "the recourse is...to detailed description of the universes and sample of treatments at hand and the testing of interactions". (p. 273)

Another way to increase the external validity or generalizability of finding in case study work is by including multiple cases. This increases the "population representativeness" (Snow, 1974) and hence the population validity. The Stake and Easley case studies in science education (Stake and Easley, 1978), for example, included eleven high schools together with their feeder schools, drawn from all parts of the continental United States. The

design of the current study includes multiple cases at each level of investigation in an attempt to increase the representativeness of the data.

In the final analysis, the validity of a case study can be judged only by the utility of its findings. This is not a new circumstance in the history of science. The form of the report and the nature of the argument will be important. Perhaps, as Roberts (1982) suggests, with additional experience with the method, we will develop a set of warrants for the methodology which will carry some of the "thinking as usual" power associated with those which back quantitative argument and research.

2.4 Main Trends in Applying Computers to Education

There are many possible models of computer use which might serve to guide teachers in their selection of appropriate computer based activities. Several models have emerged over the past twenty years which represent quite different outlooks on the nature of schooling and the teaching/learning process. While it is unlikely that a given teacher or administrator involved in the current implementation will be thoroughly familiar with all of these, the researcher must be able to recognize and catagorize activities to provide an adequate description of events.

2.4.1 The Major Types of Computer Use in Education

The applications of the wartime computers, cryptography and ballistics computation, were soon overshadowed in the early 1950's by the rapid rise of applications in business and industry. These early applications still tended toward numerical operations, with payables, receivables, and billing as prime examples. As reliability and economy of storage increased, applications such as inventory, and records storage and retrieval become more evident. These activities will, for the purpose of this document, be referred to generically as "data processing". Educational administrators were relatively quick to apply these systems to handling their problems, which had many parallels with the business world. To the extent that experience with such applications may colour the perceptions of administrators (and, as a consequence of such management activities as attendance and grade reporting, teachers) they are important in our considerations. The extensive growth of educational data processing will not be dealt with further. It has been raised at this point only that the reader may be conscious that such pervasive activity may alter perceptions of the computer as an educational tool.

Three areas of educational computer use will be examined in this chapter. For the purpose of this study, they will be identified as "computer assisted instruction" or CAI, "computer managed instruction", or CMI, and "computer aided learning", or CAL.

2.4.2 Computer Assisted Instruction

Early proponents of computer use in education viewed the computer as a device to replace a part of the conventional role of the teacher, as a drill master and as a tutor. This activity has been dubbed "computer assisted instruction, or CAI. Though the term has been variously interpreted in both broad and narrow conceptions, the norm of activity conducted under this rubric tends toward fairly clearly defined parameters. For the purpose of this study, the term CAI will be used to describe systems which either drill, based on predetermined answers, or employ a predetermined instructional logic featuring choices between set alternatives, matched in turn to paths through succeeding logics. Various algorithms may be used to effect the matching, but the number of alternative routes are in general finite and small.

Such use, at least in North America, has become the predominent form of direct involvement of computers in the teaching/learning process. The term "computer assisted instruction" is a preferred descriptor in the ERIC system. As such, it is frequently used in its broadest sense. Because the term "instruction" connotes a certain conceptual model of learning, owing much to behavioral psychology, this author prefers the narrower definition of CAI as featuring predetermined instructional logic.

2.4.2.1 Historical Review of CAI

One of the earliest references to the use of the computer in instruction was by Rath, Anderson and Brainerd (1959), who reported a project in which an IBM 650 computer was used to teach binary arithmetic to students.

Early instructional applications on general purpose computing systems gave way in the mid 1960's to systems employing hardware and software specially designed for the instructional task. The development of the PLATO project at the University of Illinois (Bitzer, 1968) and of the IBM 1500 system were major developments in the 1960's. The IBM 1500 system, which had a number of advanced characteristics for its time, including multiple character set capability, good quality graphic display, as well as direct control of audio units and film projectors, saw service in a number of locations. According to records of the Division of Educational Research Services, the University of Alberta, some 25 such systems were installed. The last operational system, at the University of Alberta, was taken out of service on April 10, 1980, after twelve years of operation. The Division records show that over 20,000 people had used the system in the interval, and instructional programming was available for 17 University courses.

PLATO, meanwhile, was developed through a number of models, with PLATO IV representing the state-of-the-art in currently available large scale systems. There are currently at least 20 PLATO systems installed world wide (Szabo, 1981).

Another major instructional computer system was developed by the MITRE corporation called TICCET (Time-shared Interactive Computer Controlled Educational Television). Both PLATO and TICCET received substantial funding from the National Science Foundation in the early 1970's.

2.4.2.2 Critique of Progress

Practioners in the educational computing field have adopted a wide variety of stances with respect to the practice of CAI. Hooper (1978), for example, describes the "narrow stereotype of computerized programmed learning" as a possible "historical aberration". Papert (1980) speaks of the computer "...being used to program the child."

> "In my vision, the child programs the computer and, in doing so, ... acquires a sense of mastery over a piece of the most modern and powerful technology ...." (p. 5)

Bork and Franklin (1979), in an overview of potential uses, note that drill and practice is a function of most conventional educational procedures, and that well designed computer dialogue can serve a useful educational purpose. At the same time, Bork

(1981) has pointed out that many "interesting learning materials" cannot be run on some of the large scale CAI systems.

This researcher tends toward the arguments of the latter authors suggesting a valuing of CAI techniques that are well constructed and well thought out, for those curricular purposes for which they are appropriate. At the same time, it is evident that much of the material available for the microcomputer at this point in time does not fit these criteria. The concern expressed by Bent(1980), that much of the research into effective instructional use is being ignored, seems valid. Yet expectations that the teacher can sucessfully intervene to improve the quality of these materials should be questioned. Hunka (1981) has pointed out that development of quality instructional material on microcomputers requires considerable time and effort. In addition:

> "For the most part, software available on microcomputers requires far greater understanding of the structure of the computer than that which is required for effective use of a large-scale computer." (p. 9)

This implies, as a corollary, that in assessing the potentially useful role of the microcomputer in the classroom a much wider range of computer based activities should be considered in addressing the needs of the entire curriculum. This view may not be consistent with that of the teachers currently engaged

in school computer use.

The extent to which the focus of computer based education has shifted away from the use of the computer for tutorial instruction evaluated through the positivistic pardigm is graphically illustrated by an examination of the literature indexed in the Cummulative Index of Journals in Education since 1978. A computer search on the descriptor Keywords "computer" and "instruction", on all entries from 1978 through July, 1981, resulted in 317 citations. The information available in the abstracts was used to catagorize these citations. Only six percent of the 317 citations described experimental studies of conventional CAI activities. A further twenty-eight percent described conventional CAI but did not indicate any experimental findings. The remaining citations were primarily devoted to describing applications requiring special hardware such as videodisk (nine percent), or applications involving adjunctive use of the computer for such things as teaching computer literacy, calculating laboratory results, controlling laboratory apparatus, or exploring concepts through special simulations (fifty-seven percent).

Of the experimental CAI studies reported in the CIJE, one-third were in journals sufficiently far removed from the mainstream that they are not held in the Education Library at the University of Alberta. The

thirteen remaining studies were retrieved and analysed.

Of the thirteen, eight were studies involving very short (less than one week, several less than one hour) use of the computer as a learning device. Nine of the thirteen described university level instruction, three were high school level, and one was basic education for functional illiterates. Only three reported using computer systems specifically designed for computer aided instruction.

There have been a number of fairly comprehensive reviews of CAI effectiveness research. Spuck (1981) cites a number of such reviews in coming to the conclusion:

> "Examination of the literature on evaluation of CAI applications leads to the conclusion that it can be as effective as good 'live' teaching. There does not seem to be a loss through the use of CAI. It should be recognized that we are just beginning to learn how to use CAI effectively, and how to use it in conjunction with other forms of instruction to maximum benefit .... The evidence on achievement, retention, and learning time is supportive of CAI, both as a supplement to and a replacement for traditional and other technology-based instructional strategies." (p. 12)

Supportive findings not included in his review have been reported by Kulik, Kulik, and Cohen (1980) and by Vinsonhaler and Bass (1972), among others.

It seems likely, as has been implied by Eisele (1980), that the verdict is in that computer assisted instruction, on average, holds some promise for education. He stresses the need to evaluate the

technology, not on the basis of "replicable learner performance" but rather on the fidelity which can be achieved to the "ideal" method for carrying out the instruction. This is a theme on which this author has touched elsewhere (Abell, 1981a). The promise, based on studies involving mainly large scale and specially designed CAI systems, may not translate easily to the microcomputer environment, however. In addition, the research offers little practical guidance. Nievergelt (1980), has pointed to the limitations of research efforts in approaching the field:

> "CAI is a field where experience and common sense are the only guidelines. There is no relevant theory to guide the designer, administrator, or user. This insight came to the community relatively late, after a decade of domination by education and psychological theories. The main lesson the CAI practitioner can learn today from these theories which were fashionable during the 1960's is to avoid their major mistake by not imposing a straight-jacket on an emerging field, restricting it to a few rigidly defined teaching strategies, before a sufficient number of alternatives have been tried.
>
> "The current lack of theories, although understandable, makes it difficult to say anything conclusive in the field. Almost any assessment of the computer's abilities as a medium for delivering instruction is based on personal experience in a particular environment. It is almost never possible to prove anything in a scientific sense, despite controlled experiments."

Systems development for CAI applications appears, on the whole, to be at about the level of large scale systems of the late 1960's. The role of the classroom teacher in shaping the evolution of these systems remains unclear

in the current literature.

2.4.3 Computer Managed Instruction

Computer managed instruction involves a broad range of activities which may include on-line diagnostic and summative testing, automatic test generation, test scoring, record keeping, scheduling of learning activities, individual learning prescription, and aspects of learning resource management.

One can predicate the growth of CMI as stemming from three different but interacting sources. On the one hand, increased concern with teaching for individual differences during the 1960's led to the development of a number of specialized instructional programs which attempted to achieve their objectives through modularized packages of instruction with frequently complex schemes for routing of individual students through the material. Individually Prescribed Instruction (IPI) (Bolvin, 1970) and Project Plan (Flanagan, 1971) are among the best known of such programs. Both systems employed computers to assist in managing student activity.

A second source of interest lay in the recognition, early in the evolution of CAI, that monumental effort would be required to present any significant volume of instructional material in CAI tutorial mode. CMI offered some of the diagnostic and activities management advantages, without the very heavy investment in courseware development.

Third, the logistics of supplying computer support for CMI were much less complex than for CAI, since a very limited amount of machine time was required per student.

2.4.3.1 Historical Review of CMI

Many programs developed in the 1960's and 1970's utilized packaged units of instruction characterized by sets of learning objectives and criterion referenced testing. Some of these programs required extensive computer support. Project PLAN (Flanagan, 1970; 1971) used a computer to integrate information on students' past achievement, interests, and abilities, teacher recommendations, and parental wishes. The result was a Plan of Study (POS) which served to guide the learner through a series of Teacher-Learning Units (TLU's). For a given specific set of objectives, several alternate TLU's might be available. Between the years 1966 and 1970, the program was developed to include instruction in science, mathematics, social studies, and language arts for grades one to twelve inclusive (Flanagan, 1971/2). The computer services were included by Flanagan (1971) in a list of "basic" components. The role of the computer was to assist in planning programs for each student, and in monitoring individual progress. This was implemented through a medium-sized computer and terminals in the schools (Baker, 1971).

Over the years a number of systems were devised to carry out this type of instructional management. PLM on

the PLATO system, RSVP at the Miami-Dade Community College (Kelly and Anandam, 1978), the CAISMS system developed by the US Navy (Pennypacker, 1978), and TAIM (Westrom, 1974), developed at the University of Alberta, are representative of many of the features of these systems. Most were intended to support packaged instructional or lab based material.

2.4.3.2 Critique of Progress

The entire effectiveness of CMI is predicated upon the existence of a well structured set of interlocking learning materials. Regardless of the computer capability, if the materials are ineffective instructionally, the result is poor quality instruction. The design of the early systems also left much to be desired. Early versions of CMI systems tended to be batch oriented with upper case only line printer output. In many cases the input of student test scores relied on clumsy and somewhat low accuracy mark-sense cards. Alternately, a teacher or aide might be employed entering results on a single remote terminal. Limited instructional logic was available on some systems. Westrom's TAIM system (Westrom, 1974) addressed this problem directly, but at the cost of considerable complexity from a naive user point of view, as well as high operating costs. Costs and logistics associated with the need for access to large central computers mitigated against widespread use of CMI in the public

schools. The implementation of individually paced instruction in the absence of such computer support has proved problematic. Locally, such self-pacing has largely dissappeared.

The advent of the classroom microcomputer has, to an extent, rekindled interest in "tactical" record keeping of student performance, and some movement in the direction of CMI might be expected to occur. A small amount of Computer Assisted Testing, which this author views as a subset of CMI, does appear to be occurring. Yet teachers might be expected to exhibit a reluctance to return quickly to the self-paced environment CMI implies. In the short term, one might expect to see intermediate forms of CMI which assist the teacher in testing and record keeping while preserving the lock step, large group orientation to instruction. Patterns might be expected to vary substantially in schools involved in programs featuring higher levels of student self-direction.

2.4.4 Computer Aided Learning

In this mode of computer usage, a student discovers information or concepts through activities such as computer simulation or through programming of his own algorithms. The use of the computer for calculation and/or for checking of laboratory results is often included under this category. Certain aspects of the task of learning to program have

impicit within them generalizable concepts applicable in many areas of the prescribed curriculum.

2.4.4.1 Historical Review of CAL

The use of computers for purposes appropriately described as computer aided learning has a comparably long history although it was largely overshadowed in the literature by the more prevalent applications of CAI and CMI through the 1960's and 1970's.

Kotak and Goddard (1966) described a project in which about 600 students from grades 8 through 12 were given an opportunity to learn some programming and to write simple programs to solve problems with "direct application to their current courses." They stated that six months after the machine was no longer available "on their own they [students] have continued to design programs for computers, in spite of the fact that they know they are unlikely to have immediate access to the machine". They describe a situation in which a student improved his physics lab experience by writing programs to process his result. This enabled him to both record many more observations than would normally have been possible, and at the same time handle his data in a much more effective manner. In another instance, grade 8 students used the computer to study complex addition series, resulting in a general increase in intellectual curiosity about the phenomena, leading to extended library research and "new insights into not only

mathematics, but also history and philosophy".

Papert and Solomon's (1972) paper, "Twenty Things to do with a Computer", emphasizes the potential value of departing from a view of the student/computer interaction in terms of words and symbols to an interaction in terms of a concrete realization of their computer activity through control of physical devices including a mechanical robot called a "turtle" and a simple music generator. Papert's work has spanned more than a decade, and is now reflected in the widening availability of the LOGO language which is in part his creation. His recent (1980) book, Mindstorms , espouses the provision of powerful computing concepts to young children as a vehicle for extending their intellectual grasp.

The use of the computer to simulate events is a special form of CAL which may have particular application to science education. In learning simulations the student exercises decisions which then result in consequences for the system simulated.

The student learns either by observation and analysis of the data returned by the simulation, or by practicing manipulation of simulation inputs to control the simulation toward some specific outcome.

Early use of simulation for teaching involved role playing, often between groups or "teams". Jacobs (1950) described the use of sociodrama, a form of event

simulation, for teacher education. He saw the learning value as a consequence of intense human-relationship dynamics manifested in an environment where ego-defenses were lowered because the situation was that of a game. In addition, because simulations allow the trying of techniques where mistakes can be erased, a wider variety of actions and consequences can be explored.

Computer based simulations have been reported in the literature since the late 1960's (Wing, 1968; McKay, 1969; Abrahamson, Wolf and Denson, 1969). Braun (1970) described a number of science simulations which allow students to carry out simulated experiments where problems of expense, complexity, measurement, or danger preclude use of real laboratory experiences. Boblick (1971) suggests that in some laboratory experiments the important concept learning may be lost in an overemphasis on specific psychomotor skills which may be of questionable relevance in the field of science outside of the classroom. In considering the use of simulations as possible replacements for laboratory activity, it would be prudent to analyze ones intents. Hofstein and Lunetta (1982) have noted laboratory instruction as an area requiring considerable additional research.

Recent work in the use of simulation for instruction has been described by Bork (1976, 1979, 1981), Liebl (1980), Zimmermann (1979), Wu (1980) and

Summers and Willett (1980).

2.4.4.2 Critique of Progress

The advent of the personal microcomputer appears to have given considerable impetus to the development of educational applications which are best described as computer aided learning. At the same time, certain problem areas can be identified.

First, the notion of providing the student with experience in programming requires extensive long term use by the student, usually with a high machine-to-student ratio.

Second, the tools provided should be non-frustrating and should represent a good fit between the real world of computing and our best knowledge of how students develop concepts important to this study. Authors such as Papert and Bork have argued persuasively in favor of the use of modern and powerful computing languages for the introduction of concepts to students. The facilities they espouse are not yet the norm in terms of availability.

Third, comparatively little attention appears to have been given, at this point, to the problems of training adequate numbers of teachers to deliver the required instruction and tutoring.

Fourth, there appears to be a dearth of research in the area of concept development as related to learning fundamental computing concepts in the K to 12 grade

range. In the absence of such research, curriculum development activities lack appropriate guidance.

Fifth, the relationship of computing concepts to specific content areas such as the natural sciences remains largely unexplored.

In the area of simulations other problems arise. Perhaps most important of these is the inadequacy of some simulations in faithfully representing the phenomena under study. Oversimplification could lead to the learning of erroneous information.

A related problem is that the development of good simulations may require considerable programming expertise and fairly powerful computational capability. In addition, simulations seem unlikely to provide an adequate learning experience if not integrated into a total set of activities including prior instructional preparation, well structured guide books, and appropriate follow-up activities. Few current materials available to the schools provide adequate guidance for the teacher or student.

2.4.5 Summary

Taken in total, the cumulative literature on computing applications in education is voluminous, extending through over two decades and including thousands of papers and reports. By differentiating the three areas of CAI, CMI and CAL one is able to show three quite different perspectives

on the relation of computers to the process of curriculum and instruction.

In the CAI mode the computer largely supplants the role of the teacher as the source of the content of instruction. Rather, the content is presented by the program as a series of information displays, with frequent questioning to monitor progress and control the presentation. The development of techniques in this area tends to parallel the developments of instructional science / instructional psychology.

A CMI approach preserves some of the teacher's content role, adding other instructional methods, while providing a potentially powerful tool in administrative support of the learning activities. Highlighting the teacher as manager, this approach tends to emphasize individual learning styles and flexible pacing.

The CAL approach is less clearly defined, tending toward the structuring of new and novel learning experiences within a conventional classroom context. Since the content of learning can remain largely unaltered under this model it would seem the most likely to be rapidly assimilated. The constraints described in the previous section may mitigate against such rapid assimilation, however.

2.5 The Question of Technology

To this point, the adoption of computers in the schools has been largely a slow and fairly cautious experimentation having little overall impact on the process of education. Computers have been expensive, mysterious, and largely inaccessible. The situation in the 1980's is rapidly changing.

2.5.1 Economics and Marketing

Madden (1980b) has provided a comprehensive analysis of the changes in the whole area of computing which have followed from the development of the "computer on a chip". The result has been a veritable "explosion" in computer numbers, such that the inaccessible has quite suddenly become not just highly accessible but also extensively and vigorously merchandized. At the same time, there has been a rapid adoption of computing devices in the work place in the form of word processors, point-of-sale terminals, and even automobile diagnostic systems.

One could view the importation of these devices into the school as a direct consequence of these marketing and economic factors. This sets up a number of tensions in the school system. The growing importance of the computer in the workplace of the high school graduate dictatates attention to the provision of computer skills in areas such as business education. Academic areas which may yet be seen as largely college preparatory are not so directly challenged.

Economic pressures, however, lead to a view of the computer as a cheap and controllable mechanism for student instruction, possibly as a way to temper escalating labour costs.

2.5.2 Leading Interests and Problem Conceptions

Heidegger speaks of a "stultified compulsion to push on blindly with technology or, what comes to the same thing, to rebel helplessly against it and curse it as the work of the devil". Such reactions perhaps typify a larger proportion of humankind in general, and teachers in particular than would be devoutly desired. There is a danger, in the rapid implementation of the computer in the school, that these two poles of action might represent the main directions of focus.

Jones (1980) has called for humanists to become concerned and knowledgable in the use of computers.

> "The cultural split between the arts and humanities and the sciences has opened a societal crack through which factors important to the quality of human life are slipping...While recent developments in computer science are not the only scientific developments creating unexamined societal effects, it is an area deserving attention".

Garson (1980) has sketched five scenarios to the year 2000 which consider possible impacts of computerizing the American educational system. These projections stress the interplay between technological development and the social and political milieu. These futures range to an extreme where the computer is used as an instrument of control by

removing the influence of the individual teacher. The world of Julia's Dilemma (Madden, 1980) is equally frightening: It would be a sad joke on humanity if Nietzsche's Overman turned out to be a maze of wires and very large scale integrated (VLSI) circuits. At the same time, we need to be mindful of our relationship to technology and to ourselves. As Heidegger has put it:

> Man . . . is continually approaching the brink of the possibility of pursuing, and pushing forward nothing but what is revealed in ordering, and of deriving all his standards on this basis. Through this the other possibility is blocked, that man might be admitted more and sooner and ever more primally to the essense of that which is unconcealed and to its unconcealment....
> (Translated by Lovitt, 1977)

It is perhaps poetic that in the electronic computer is the essence of a positivistic logic created, as it were, in the image of its Creators. Man has remained largely in control of the situation through power over the input of information to the computer. As the relentless push of the essence of technology dictates the evolution toward an expanded sense world for this electronic "being", electronic ears, eyes, and voice, so we come closer to the "danger" of which Heidegger speaks.

Chapter 3

RESEARCH METHODOLOGY

In approaching this particular study of a complex innovation, the researcher was presented with a dilemma. The activity under study appeared to be very widespread, yet very diffuse. No clear "plan of implementation" appeared to have been formulated. No particular schools were clearly exemplars of the implementation.

Furthermore, in keeping with the researcher's methodological and philosophical bias toward a broad "open systems" world view, a research model was required which would allow sufficient breadth of study to fairly characterize the myriad forces brought into play while at the same time focussing to a sufficient extent to truly determine the nature of events at the level of the science classroom.

3.1 The Research Model

The research model which was adopted may be viewed as a series of boxes within boxes, rather akin to the old party joke of enclosing a small gift in a small wrapped box, which is then packed into a larger box, which is then packaged in a still larger box, and so on, until on the outside it appears as a very large present indeed. The researcher, conducting research under this model, like the gift getter, always faces the possibility that, when he finally opens the last box, it will be truly empty.

The research model used in this study is shown in Figure 1. At the outer level is the largest box which seemed manageable for purposes of the study -- the metropolitan district encompassing the city of Edmonton. From the viewpoint of open systems, of course, there are yet larger boxes, the region, the province, the country, and so on ad infinitum.

There is justification, however, in studying implementation of an innovation at the district level. Studies of innovation diffusion strongly suggest that personal contact is very influential in the spread of innovations (House, 1974). Thus the implementation of innovative programs tends to be characterized by geographical clusters around major metropolitan centres.

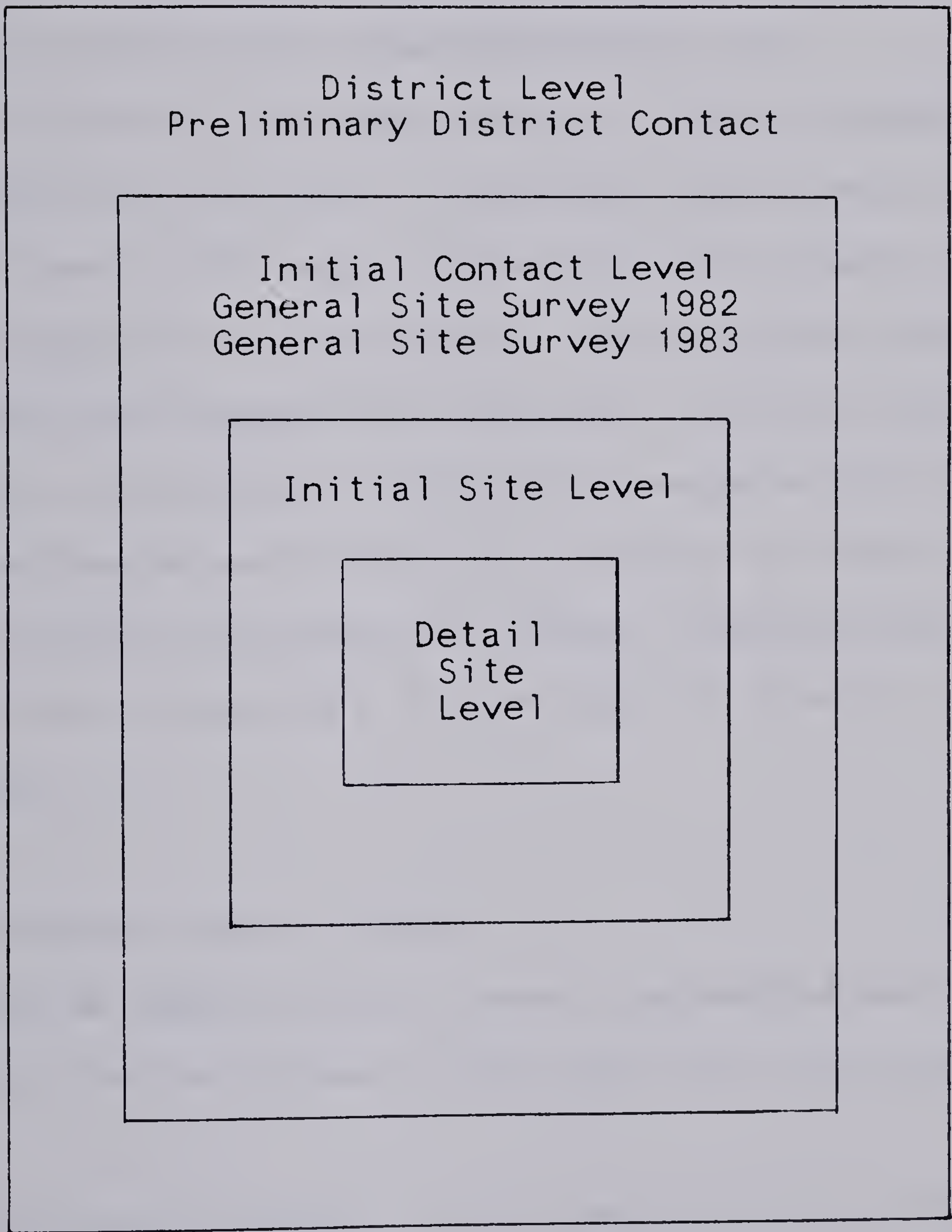
The metropolitan district is thus conceived as the outer level of the research model. In a few instances within this study report, observations and inferences pertaining to the provincial level may be made, but these arise largely from perceptions drawn at the inner levels of the model.

3.2 Preliminary District Contact

Within the metropolitan district there are several school jurisdictions. The researcher selected four of these, using as criteria both size and familiarity to the researcher. Using familiarity as a criteria clearly could introduce bias. However, in a case approach of limited duration, entry to and credibility within study sites is a

FIGURE 1

A CONCENTERING MODEL FOR CASE RESEARCH



critical concern, and seemed best served by limiting the study in this manner.

One of the four local jurisdictions was subsequently dropped from consideration, as local officials advised that there was no activity occurring there which fit within study parameters of computing activity in science education.

Initial activities involved contact with representatives of the three remaining school boards. In the two larger jurisdictions, an individual was identified at the board level with major responsibilities toward the use of microcomputers in the schools. Brief meetings were held in November and December of 1981 with the identified individuals, and copies of documents prepared for their respective boards were obtained. Portions of these documents, which represent the stated intentions for the introduction of computers in the district schools, are found in appendix A.

3.3 Preliminary School Survey

Based on these district level discussions and documents, the next phase of the study was carried out as follows:

1. A list of all schools in the Edmonton Public, Edmonton Separate, and County of Parkland school divisions which had microcomputer equipment was drawn up. Information to compile these lists was obtained from appropriate school board sources for each district.

2. The principal of each junior and senior high school on this list was contacted. This involved telephone contact with forty-seven schools. Questions with respect to the number, disposition, and use of microcomputers within his/her school were asked, with special attention to science use or projected science use. A copy of the interview guide is found in appendix B.
3. The names of school based coordinators of computing activity and of involved science teachers were obtained where available.

This general survey was carried out in February and March of 1982, both to select schools for further study and also to provide a broad perspective on the degree and type of school involvement in the study area. Some findings of this preliminary survey are reported in chapter 4.

3.4 Repeat of District School Survey

In January of 1983, a general survey was again carried out by telephone contact with each of the forty-seven schools involved in the initial survey. This was intended to provide some indication of any shift in trends over the approximate one year duration of the study.

A copy of the interview guide used for this round of the survey is found in appendix B. Findings from this survey activity, with comparisons to the initial survey results, are discussed in chapter 4.

3.5 Initial Site Visits

From the information obtained during the initial survey a priority list of twenty schools was drawn up, attempting to combine as criteria for selection a concern for representativeness of districts, and of junior/senior levels, as well as length of involvement with the technology. The researcher received clearance to visit seventeen of the identified schools. He was denied permission to visit 3 schools in one jurisdiction on the basis that there was no substantial activity of interest in science education occuring in the selected schools.

The seventeen schools formed the initial investigation sites. Telephone contact with these schools was used to set up a schedule of initial site visits. One half-day was scheduled for each of the seventeen schools included in the preliminary investigation. In three of the schools, the researcher engaged in a structured interview with the chief administrator for the school (the interview guide is included in Appendix B). In fifteen of the schools a science teacher involved with the microcomputer implementation had been identified. A meeting with the science teacher(s) using the microcomputers was scheduled for a spare, over lunch, or after school. The timing of this meeting was cleared in advance. A structured interview was carried out. The interview guide is found in appendix B.

A visit to the staff room was carried out timed to allow an opportunity to check staff notice boards,

periodical racks, and the like, for signs of computer related material. In a few cases, the researcher was able to observe some student use of the computer, and in several cases to view the physical facilities.

3.5.1 Interview Procedure and Data Collation

The interviews were held with individuals in all but three cases, when a group of two or three teachers were involved. A quiet setting, preferably a private office, was used. In all but one case, the interviews were recorded on cassette tape. The interviewer used the interview questions as a general guide, although the order of the questions and the exact phrasing was altered in order that the interviews might be kept as conversational as possible. Sufficient latitude was encouraged through follow-up questions to try to elicit indicators of special successes, problems, or circumstances which might make the site particularly useful as a site for detailed study.

In addition to the taping, notes were taken, and, following the interview, both tape and notes were identified with an i.d. number, date, time, place, and respondents. The notes and tape were reviewed on the same day, and methodological and theoretical notes were made. The entire tape was recorded in a computer file, together with significant observational notes. This file was keyed to the original tape.

The data collected in the preliminary site visits was intended to serve two purposes. First, the observations and cumulation of theoretical notes enabled the development of working hypotheses on the crucial elements and relations involved in the implementation of the microcomputer in the school and the classroom. These working hypotheses served as the starting point for the more detailed study of a few selected sites. Second, the preliminary site visits were intended to give a broad descriptive picture of the total implementation scene and to provide sufficient data to select the six schools for more detailed study.

3.6 The Student Perspective

During the preliminary site visits it became apparent that the level of direct instructional contact in science between the computer and the student was relatively low when compared to the total number of machines and level of teacher involvement. The focus occurred to be at the level of computer literacy for students. The reasons for this will be explored in chapter 7. Suffice it to say at this point that there was little to observe in the way of science instructional use. At the same time student attitudes and perceptions of the computer seemed relevant to the purposes of the study, since student reaction was frequently cited by participating teachers. Some triangulation of the data obtained from teacher interviews seemed desirable. In order that the researcher might gain some insight into student

perceptions of the implementation, the following investigation was carried out.

3.6.1 Sites for the Study

Two schools were used to obtain the data for this part of the study. The junior high school was a small urban school drawing from neighborhoods of mixed socio-economic level. This school had been involved with microcomputers for at least three years. Ten computers were available in a self-contained classroom setting.

The senior high school used was a large composite high school in a commercial/residential area of the city. Computers are quite extensively used in this school as part of the business education program. For the purpose of the general science module which formed part of this study, however, three computers were brought from the main computer room to the science classroom each day. The students were drawn from a non-academic general science program.

3.6.2 Method

Nine groups of three students each were interviewed. The groups were selected by the teachers, who requested volunteers. The students were simply told that the researcher wished to talk to them about computers.

Four groups, two all boys and two all girls, were drawn from a grade seven math class. These students had been using the computer to learn programming one class per week for the

previous four months. Two groups, one of boys and one of girls, were drawn from a grade nine math class. This class had been taking programming for seven months. The last three groups, two of boys and one of girls, were drawn from a grade eleven general science class. They had just completed an approximately one month module on computing in the week prior to the interview.

The interviews were held in a room separate from the rest of the class. All of the interviews were taped. The researcher used a number of prepared questions as a general guide only. These questions are presented in Appendix B. The interviews, on average, took about fifteen minutes for each group. In addition to these interviews, the researcher spent some time with the teacher, visited the computer facilities, and reviewed a few samples of student programs. A copy of the just completed grade eleven unit test was also reviewed.

The tapes were converted to tapescript copy after the interviews, in the same manner as has been described for the initial site visits. The findings from this phase of the study are reported in chapter 6.

3.7 Detailed Site Study

The last two phases of the study involved more detailed investigation at a few sites, represented in the research model by the innermost box. Six schools were chosen in an attempt to give as complete a cross-section as possible of the various factors involved. The criteria were as follows:

1. both junior and senior high school levels should be included
2. the chosen schools should include those relatively new to the phenomena under study (less than 1 year) as well as those with longer experience (3 or 4 years)
3. the types of activities in which the science teachers are engaged should span a range of activities, including administrative through to science instructional use.
4. all three jurisdictions included at the outer level of the model should be represented at this innermost level.

Two further sets of activities were now carried out in these six schools, as described in the following sections.

3.7.1 Case Study of Six Sites

In this next phase of the study attempts were made to refine the hypotheses and to validate the perceived relationships across sites. For this purpose, six schools were chosen, and the researcher carried out an extended investigation, following up on the initial interviews and observations with further interviews with teachers, administrators and students. The intent was to provide a "thick description" of the contexts and local problems and problem solutions which characterized the specific site. At the same time, an attempt was made to identify more global and generalizable facets of the implementation, and to obtain through triangulation within the main study sites theory having potential pragmatic value.

On the basis of this series of visits, which were made between September, 1982 and February 1983, a case description was prepared for each school. These descriptive statements were verified with the teachers involved, and are included in appendix C. The detailed discussion of the overall findings of this study, chapter 8, attempts to draw together the information obtained from these detailed site visits, together with that obtained at each level represented by the research model. This detailed site study involved a total of thirty-two additional visits over the six sites.

3.7.2 Developing a Humanistic Model for Computer Utilization

Several teachers who were identified during the preliminary phase of the study as evidencing humanistic concerns were asked to participate in the formulation of a humanistic model or models of computer utilization in science education. The model was developed as follows. First, the transcripts of the preliminary site visit tapes were reviewed, and a series of six statements prepared which reflected teacher concerns for the humanistic application of the computer in the classroom. These six statements were prepared and distributed by the researcher to nine teachers in five of the study schools in December of 1982. This version of the document, and a cover note are included in appendix D.

In January, 1983 the researcher held taped discussions with each of the groups of teachers to get their reactions to the statements. Four were individual and two were small group sessions. These discussions then formed the basis for revisions to the original document. The revised statements are found in appendix D. This new document was distributed to ten teachers and a written response obtained. The reactions of the teachers to this second set of statements is summarized in chapter 7. The concerns raised during this portion of the study were used as input in the development of the computer implementation and usage model.

3.8 Analysis of Study Data

At all stages of the study, large amounts of information were gathered as input both to later stages of the study and to the process of writing the report. As previously indicated, taped interview material, together with attendant notes, were transcribed to microcomputer files. For the purposes of analysis, paper printouts of these files were produced.

Analysis involved reading and rereading the transcripts. Paragraphs were then singly or multiply coded in context according to their content, and each paragraph was identified by source. These paragraphs were then separated and sorted according to particular issues addressed. These sorted collections of issues statements were combined with related observational and theoretical

notes to aid the researcher in understanding each issue. By activities such as sequencing and counting of these statements it was possible to derive some quantitative as well as qualitative data. Because the statements retained identification of source, it was also possible to return to the full documents in order to confirm the meaning in full context, to triangulate information, and to examine relations between issues. Exemplary comments were extracted from the transcripts and other written documents for inclusion in the report.

Chapter 4

THE GENERAL SITE SURVEYS

The first general site survey was carried out in February and March of 1982. This phase of the study was intended to provide a broad picture of the current state and direction of computer use in science education in the schools of the study area. From this broad picture the researcher wished to extract working hypotheses on the crucial elements and relations involved in the implementation. A total of forty-seven schools were contacted by telephone and a series of questions were asked of the principal. The questions concerned the general deployment of microcomputers in the school, the involvement of teachers, and the organizational responsibility for the machines. The guiding questions for this first survey are included in appendix B.

The schools contacted were all those within the respective systems which had been identified by systems level personnel as possessing computers. Table 1 shows a breakdown by system and school level of the number of schools contacted. The researcher recorded responses to the questions on separate sheets for each school. In all cases an attempt was made to keep the contact conversational and to allow adequate opportunity for the respondent to add to or elaborate on the substance of the questions.

In January of 1983 the telephone survey was repeated, with some changes to the interview guide. This guide is also

TABLE 1

SCHOOLS IN SURVEY BY SYSTEM AND LEVEL

System	Junior High	Senior High	Total
A	17	12	29
B	9	7	16
C	1	1	2
Total	27	20	47

*Note: where grade levels overlapped the usual junior high/senior high boundary, the school has been included according to the relative number of grade levels falling within the 7 to 9 and 10 to 12 ranges.

included in appendix B. The overall results of the general site surveys have been included in a series of tables. The findings of the 1982 and 1983 surveys will be discussed separately and then some implications of the combined results will be examined.

4.1 1982 Survey and Results

The number of microcomputers actually in place or on order, as reported by the survey respondents is shown in Table 2, broken down by system and school level. The number of schools reporting involvement of science teachers with the implementation of microcomputers is shown in Table 3.

It is important to note that principals tended to exhibit some ambivalence in identifying usage in science or science teacher interest. Interest indicators mentioned ranged from teachers taking a course or inservice through to running a computer club for students, while usage indicators ranged from vague reference to computer literacy through to specification of actual instructional software packages in science available within the school. It is probably safe to conclude that for the surveyed schools slightly fewer than one-half had some science teachers involved in at least familiarization activities with the computer, and that the proportion is slightly higher at the senior high level than at the junior high level.

Responses concerning uses in various areas is summarized in Table 4. While this data may appear to

TABLE 2

DEPLOYMENT OF MICROCOMPUTERS IN SURVEY SCHOOLS - FEBRUARY 1982

System	Number of J.H. Schools	Number of Computers	Average per School	Number of S.H. Schools	Number of Computers	Average per School	Total Schools	Number of Computers	Average per School
A	17	50	2.94	12	152	12.67	29	202	6.97
B	9	31	3.44	7	47	6.71	16	78	4.88
C	1	2	2.00	1	2	2.00	2	4	2.00
Totals	27	83	3.07	20	201	10.05	47	284	6.04

(Includes machines on order at survey date.)

TABLE 3

SCHOOLS REPORTING SCIENCE TEACHER INVOLVEMENT - FEBRUARY 1982

System	Number of J.H. Schools	Number Reporting Science Involvement	Percent of Sample	Number of S.H. Schools	Number Reporting Science Involvement	Percent of Sample	Total Schools	Number Reporting Science Involvement	Percent of Sample
A	17	7	41	12	7	58	29	14	48
B	9	3	33	7	3	43	16	6	38
C	1	1	100	1	0	0	2	1	50
Totals	27	11	41	20	10	50	47	21	45

TABLE 4

REPORTED USES IN VARIOUS SUBJECT AREAS AS FREQUENCY AND PERCENT - FEBRUARY 1982

Uses Mentioned	System A				System B				System C				Totals			
	Junior High N = 17		Senior High N = 12		Junior High N = 9		Senior High N = 7		Junior High N = 1		Senior High N = 1		Junior High N = 17		Senior High N = 20	
	f	%	f	%	f	%	f	%	f	%	f	%	f	%	f	%
Science	--	--	2	17	--	--	2	29	1	100	--	--	1	4	4	20
Math	6	35	4	33	5	56	2	29	--	--	--	--	11	41	6	30
Language Arts	2	12	--	--	3	33	--	--	--	--	--	--	5	19	--	--
Special Ed																
Industrial Arts, Electronics, Etc.	5	29	6	50	--	-	--	--	1	100	--	--	6	22	6	30
Business Ed, Data/Word Processing	--	--	7	58	--	--	4	57	--	--	--	--	--	--	11	55
Literacy (or B-Option)	6	35	1	8	2	22	--	--	--	--	--	--	8	30	1	5
Computing Science	--	--	4	33	--	--	--	--	--	--	--	--	--	--	4	20
Administration, Records	1	6	1	8	1	11	--	--	--	--	--	--	2	7	1	5
Staff Training, Familiarization	4	24	--	--	3	33	--	--	--	--	1	100	7	26	1	5
Computer Club	4	24	--	--	1	11	--	--	--	--	--	--	5	19	--	--

conflict with the previous table on science teacher involvement it must be noted that computer literacy and computing science courses are being given in several schools by science teachers. The "science" category in Table 4 should be interpreted as a specific identification, by the principal, of the computer use as a "science" activity. Furthermore, the table should be interpreted as the principals' *perception* of activity rather than as a highly accurate count of specific usage. This caution not withstanding, the data strongly suggests that considerable computer activity in the schools of the study area is occurring in business education, industrial arts and math education. By comparison, computer activity in science appears to be much less prominent, at least as interpreted by the principals' comments.

4.2 1983 Survey and Results

A telephone survey of the same forty-seven schools was conducted in January of 1983. The number of microcomputers in place or on order, as reported by the survey respondents, is shown in Table 5, broken down by system and school level. Table 6 compares this information to that for 1982 in terms of absolute and percentage gain in facilities. Note that this does not represent the total gain in machine numbers across the systems as only schools included in both surveys are included in this table.

TABLE 5

DEPLOYMENT OF MICROCOMPUTERS IN SURVEY SCHOOLS - FEBRUARY 1983

System	Number of J.H. Schools	Number of Computers	Average per School	Number of S.H. Schools	Number of Computers	Average per School	Total Schools	Number of Computers	Average per School
A	17	112	6.59	12	382	31.83	29	494	17.03
B	9	60	6.67	7	121	17.29	16	181	11.31
C	1	2	2.00	1	7	7.00	2	9	4.50
Total	27	174	6.44	20	510	25.50	47	684	14.55

(Includes machines on order at survey date.)

TABLE 6

1982 - 1983 GAIN IN NUMBER OF MICROCOMPUTERS

System	Number of J.H. Schools	Gain since 1982	Total as a Percent of 1982	Number of S.H. Schools	Gain since 1982	Total as a Percent of 1982	Total Schools	Gain Since 1982	Total as a Percent of 1982
A	17	52	204	12	230	251	29	292	245
B	9	29	194	7	74	257	16	103	232
C	1	0	100	1	5	350	2	5	225
Total	27	91	210	20	309	254	47	400	241

The increase in numbers is substantial. When one takes into account the fact that schools having no computers in 1982 but which may have added computers in 1983 are not included, the numbers are more impressive. Further, these additions occurred in a year in which substantial budget restraint was being practiced in all jurisdictions.

These numbers can be compared with figures reported in a survey by Petruk (1981). He found two hundred and fifty-six microcomputers for all of Alberta at that time. The implications of this rate of growth are several:

1. Initial school experiences with the computer appear to be positive, sufficiently positive that substantial allocations of money from school based budgets are being applied to machine purchase.
2. Student demand for access, primarily for computing science and computer literacy courses still exceeds the capacity of existing facilities.
3. The number of teachers coming into direct contact with the computer continues to climb.

On the basis of principal's reports, about 450 teachers are actively involved within the 47 schools included in the survey. Science teacher involvement figures are presented in Table 7. Of particular interest is the apparent gain in science teacher involvement in system A from 1982 to 1983.

Table 8 examines reported usage within the 47 schools. These data show considerable divergence from an expectation of wide usage for direct instruction. Appendix A contains

TABLE 7

SCHOOLS REPORTING SCIENCE TEACHER INVOLVEMENT - FEBRUARY 1983

System	Number of J.H. Schools	Number Reporting Science Involvement	Percent of Sample	Number of S.H. Schools	Number Reporting Science Involvement	Percent of Sample	Total Schools	Number Reporting Science Involvement	Percent of Sample
A	17	13	76	12	8	67	29	21	72
B	9	2	22	7	4	57	16	6	38
C	1	1	100	1	-	0	2	1	50
Total	27	16	59	20	12	60	47	28	60

TABLE 8

REPORTED USES IN VARIOUS SUBJECT AREAS AS FREQUENCY AND PERCENT - FEBRUARY 1983

Uses Mentioned	System A				System B				System C				Totals			
	Junior High N = 17		Senior High N = 12		Junior High N = 9		Senior High N = 7		Junior High N = 1		Senior High N = 1		Junior High N = 17		Senior High N = 20	
	f	%	f	%	f	%	f	%	f	%	f	%	f	%	f	%
Science	2	12	5	42	1	11	1	14	1	100	--	--	4	15	6	30
Math	6	35	4	33	2	22	5	71	1	100	--	--	9	33	9	45
Language Arts, Special Ed.	3	18	2	17	1	11	1	14	1	100	--	--	5	19	3	15
Industrial Arts, Electronics, Etc.	5	29	5	42	2	22	3	43	1	100	--	--	8	30	8	40
Business Ed, Data/Word Processing	--	--	7	58	--	--	7	100	--	--	1	100	--	--	15	75
Literacy (or B-Option)	13	78	2	17	5	56	2	29	--	--	1	100	18	67	5	25
Computing Science	--	--	8	67	--	--	3	43	--	--	--	--	--	--	11	55
Administration, Records	8	52	5	42	2	22	--	--	1	100	1	100	11	43	6	30
Staff Training, Familiarization	1	6	--	--	--	--	--	--	--	--	--	--	1	4	--	--
Guidance	--	--	1	8	--	--	--	--	--	--	1	100	--	--	2	10
Club	5	29	3	25	--	--	1	14	--	--	1	100	5	17	5	25
Music	--	--	1	8	--	--	--	--	--	--	--	--	--	--	1	5

examples of some report and request documents which have been generated within the study area. In all three, prominent mention is made of direct instructional use in core subject areas. The first issue of the Alberta Education newsletter "Computer Technology (Vol 1 #1, May 1982) placed a strong emphasis first on hardware, and second on the availability of instructional courseware. Alberta Education has established a "courseware clearinghouse" for the examination of instructional material for the computer. Their mandate does not include the evaluation of administrative or management software which is not directly related to instructional software. (Thiessen, personal communication).

This chapter has attempted to summarize the information obtained at the outer level of the research model. Before attempting to attach meaning to this data it is necessary to look at the next level of the research model, the preliminary site visits. This stage of the research is discussed in chapter 5.

Chapter 5

PRELIMINARY SITE VISITS

In chapter 4, a telephone survey of area schools was described. The next phase of the study involved actual site visits to 17 schools chosen from the 47 included in the telephone survey. The methodology has been discussed in Chapter 3. The primary criterion for choosing the sites was the report of definite science teacher involvement with microcomputing. Guided interviews were held with Science teachers and/or administrators in each school. The interview guide is included in appendix B. The interviews were taped and the tapes transcribed. From the transcripts, and from direct observations recorded by the researcher, an attempt was made to categorize the major issues involved at that point in the implementation.

In examining the interview data, four major categories of interest were identified.

1. Why do teachers become involved in a microcomputer project?
2. What factors operate to sustain or to lessen their interest in continuing?
3. What directions are they pursuing at present and why are they focusing attention in these directions?
4. What is their "vision" of the future, and how does it relate to their current pursuits?

This chapter examines directly possible answers to the first two questions, based on responses obtained during the

initial site visits. The question of current focus and future directions will be pursued in chapter 7.

5.1 Why Teachers Become Involved

Involvement requires first of all an awareness of the phenomena. Teacher interest then might be expected to largely depend on their perceptions of the value the phenomena might have for them and for their students. Countering the tendency to become involved are teacher fears or concerns, which might range from the seeming irrational through to the highly practical. Of course, what appears highly irrational to one may be totally rational to another. It is not the role or the intent of the researcher to be judgemental. Rather, the intent is to describe the situation as perceived.

On the basis of teacher reports most of the teachers currently involved developed their interest in the area either through exposure to computer education courses or through the work of collegues. For some, the source of interest goes back a long way. One teacher, who in turn has been influential in introducing computers into his jurisdiction, took a course at the U of A in the late 60's or early 70's on the IBM 1500...

> I thought "gee, this is great, this has real potential" ... except you find out that the price tag on that thing is so prohibitive that you'd never get to use it in the classroom. So when micros came out for about a thousand dollars a hit I figured well, let's give it a shot and see what we can do to approximate that system.

He purchased a machine of his own, wrote a small program, and brought it to school.

> ...and the thing just took off. The kids did the program and said "well yeah, that's great. How do you make this thing work?... and before I knew it I had a good half-dozen kids lined up every night just to try and work some stuff on the machine.... The demand has been from the student end... it's not unique to this place. I've heard a lot of nice little stories from other places, students raising a thousand dollars, plopping it on the principal's desk and saying go buy us a computer...

Other University activity has also played a role:

> That's sort of interesting because when I was back in university, two years ago - I had a sabbatical - and I had no interest in computers at all because I'm a science man. And it just so happened I was taking a course of Dr. Aoki's, 549-550, and one of the gentlemen in the class was very heavily involved with computers when Dr. Aoki asked us to do a workshop, to form small groups. Well, I had some things in my mind, but I hadn't really formed anything concrete, but this other gentleman who was working in the computer division asked me if I would join him and another fellow in working on a workshop on computers in the schools. So anyway, I and another chap got involved and we put together a little workshop for the course for teachers. And of course, XXX was the driving force there - he got the machines - but we worked together on the project and then presented it to the teachers. And it really got me thinking. It really got me thinking because it opened up a totally new world to me.

Marketing pressures have also had their effect, although this situation is probably very unique:

> That actually occurred some almost 12 years ago, so the roots are kind of hazy ... At that time we had, I don't even know why it occurred, but we ended up having a PDP-8 in for May and June on loan from the Digital people ... the old, you know, teletype, everything else, and we had a hell of a lot of fun with that for the couple of months, sometimes till early in the morning there were kids here and staff here. It looked like it was going to cost about twenty-thousand ... you know, that's in - however long ago it was, and it was decided it was just too much money ... It was located in the building and

> ... primarily we were trying to get at it to do some programming studies right away ... because we knew it was only here for two months. And then things languished for a long time although the people that were involved then (there were 3 or 4 of us) were still around say 3 or 4 years ago and from time to time we would approach the people or try and keep up with what was happening to see whether we couldn't try again. And one year it was mentioned to me that there were some "surplus funds" in the school and they would entertain positively a proposal. So really, I suppose, that's where it began was at that point... I went around to a number of different places in the city and there weren't many at that time who were involved and on that, then, we based our proposal....

In very recent years different forces have been at work, and they appear to have a differential effect. Government became interested.

> I guess the chairman of our committee was aware that the provincial government, the Department of Education, was starting to look ahead into the computer field. And I think that's when I became aware of the particular film, "Now the chips are down", and when I saw the sorts of things that the computer was beginning to do, you know, I could see the writing on the wall.

Contact with collegues through formal and informal networks tended to spread the innovation.

> I went to Physics Council and I had heard about these things before but a person doesn't really see what the capabilities are until you see somebody doing something ... and that's what I happened to see. . . . As I say, he was showing what the kids had done, so we weren't looking at super high quality stuff but the idea that there are some things you can do in the science area using microcomputers that you can't do using AV or using demonstrations or labs for one reason or another .... Al, the fellow I was talking to, I think he had - it had hit him considerably sooner than it hit me because his son had one at home. ...

Over time, press coverage of developments and projects created a public expectation. This exerts pressure at a

number of levels.

> Well, you know, you pick up the paper and you see that they're coming in and they're the thing and ... let's get with it or maybe you won't know something that you should be knowing and be able to use it.

Societal pressure tends to build up on the local school, and the principals react.

> The point that I am trying to make is that 'out there' there is a considerable amount of interest I perceive in the computer, whereas the reality of the situation is that we as a school system are not reacting all that well to it, although it is in the dry off stages and there is no way that you can say that something should take off all at once. I've seen too many things in education go too far too fast and explode in peoples faces like modern math. And I am glad that this is not happening here.... We had a parent meeting on last week and there was some criticism ... that things weren't happening fast enough. There was also some criticism that I had no plan of action and they don't realize that it is a very sensitive kind of thing and they also don't understand that it's easy to throw stones and it's darn tough to catch them and I'm having to catch the stones that they're throwing with the idea of running with them somewhere. To run with them is not easy....

Inevitably, in some schools, it is perceived as a top down innovation. The reaction is predictable.

> You're presuming we're using them! We have microcomputers in the school and the way we got involved is our principal brought them in. He exposed us to them and asked us if we wanted to take a week mini course on how to use microcomputers ... but that's as far as our involvement has gone.

Another teacher started with a machine at home.

> ...I primarily got it, I would think, because of word processing capability, because of my work as an author, and because of ... my PhD .... And you could... list all kinds of other reasons as well. And I suppose ... that was one of my main reasons for getting it at school as well. ...And that's where I have been primarily kind of helping the department along in that particular area ... in word processing. I've kind of concentrated on that....

Several respondents have reacted strongly to observations of the behavior of children, particularly their own children.

> So anyway, we got this Apple home and we saw what it did for my kid. I knew nothing about it; he knew nothing about it, and now he's into machine language programs. I mean, he's starting to work on games that he thinks will be saleable - well I don't know if they ever will be, but he's gotten to the point where he's getting very good at it, and I saw what it did to him in terms of providing an outlet for his energies that he wasn't getting in the traditional school setting, and I thought to myself, Hey, for the brighter kids that are bored in my classes, this is the kind of thing that ... they need. Something that will really challenge them.

5.1.1 Summary of Involvement Mechanisms

In summary, the following mechanisms can be identified as significant in encouraging teacher involvement with microcomputers in the schools:

1. previous exposure or interest in computers prior to the arrival of microcomputers through:
    a. courses in computer education,
    b. courses in computer science,
    c. other external exposure including non-teaching employment.
2. collegial contact with microcomputing including planned inservice.
3. contact in a home environment.
4. external pressure and publicity including student demand and government interest.
5. internal administrative pressure.

5.2 Factors Involved in Spreading the Implementation

Fear of the machine may be a factor slowing the spread of the implementation. It is perceived as a factor by a number of the respondents.

> What we were trying to do is ... familiarize some of the people who were interested so it wouldn't be a frightening kind of thing... A lot of teachers are . frightened by new things....
> In the county, and in the school I would say that a lot of teachers are afraid of the computer. They aren't afraid of it as far as replacing them; they're afraid of it in that they don't know how to make it work.

A department head put it this way:

> They're still frightened as hell of the machine, period. Now in three years, however, I now have the expression of opinion as follows: "Well you know, I think I'm going to have to learn something about this." This would be, say, a math teacher talking. And I think that that's positive. But it takes time.

From a principal, comes this comment:

> I have one science person who is about 5 years from retirement and his attitude is "I just hope it runs away so that I don't have to deal with it."

The overall impression that one gets, however, is that "fear of the machine" is probably a less important determinant of involvement now, in the age of the microcomputer, than it was perhaps five years ago. Microcomputers are sufficiently commonplace now that large numbers of teachers have had some contact with them. The more important question is the value which the teacher sees in becoming involved. For some, the key is in the provision of administrative support at the classroom level.

> It's making me a better teacher now because it allows me to see that, whereas when I get a mark for student x and it says 63, it doesn't really tell me

> a lot and I have to go through a mark book which is many many pages long but when I get it all neatly printed all in one long column, its right there before my eyes. It's worth it right there. If it didn't do another thing, that's enough.

Teacher perceptions of high student interest in learning programming is commonly described. For many teachers, "computer literacy", largely, it appears, interpreted as learning to program, is the main application of the computer in the classroom at the present time. This is particularly the case in the junior high schools, where teachers see computer literacy courses as an appropriate "B" option in the science area. In the high schools in the study area, one notable example was found of a computer literacy module in the non-academic science stream. At the high school level, however, responsibility for "computer education" courses is found in various departments. Business Education is the most common location, as the activity is seen as a logical extension of business data processing. This is accentuated by the provision of special funding through BQRP grants, which have been responsible for some of the larger acquisitions of machines. Some science teachers question this emphasis.

> Right now it's business ed. I teach certain aspects of it as business ed. Others I don't at all.... [The course is taught] within the Business Ed. Department, but I don't teach it as a business ed. course; I teach it as a computing science course. I tell you, it's a bit of a problem in that opinion at the school board seems to be that this is a business education course, which computing science is not. The problem is it only looks at a limited application of the whole area of computing science as such when you do it that way.

The resolution of this particular issue may well affect usage models within science education in the short term. It is having an effect now in the organizational placement of machines.

5.2.1 Problems in Implementation in Science

From the outset it was clear, at least in the area of traditional science education, that the total cummulative effect of computer usage with students is very limited at present. Science teachers in 15 of the 17 schools identified insufficient numbers of machines as a major problem in utilizing computers with their science classes. It should be noted that in the schools having close to a class set, in no case are these located in the science department. In only four schools of the seventeen was one or more machines regularly located in the science area, a total of five machines out of 149 available in the schools.

Particularly at the high school level, teachers seem reluctant to break up class activity by having only a part of the class access the microcomputers at a time. They look forward to a day when a class set will be available as a computer lab.

> By that time, we should have a full classroom set. So it should be possible to schedule various classes to go down there at various times to actually learn various things from it. I find that even the equipment that I have in this classroom right now and actually no teacher assistance and it's just - the equipment is a real pain. So, I wouldn't want to have to drag the stuff from one room to the other....

> I don't expect to become more involved unless the number of computers in the school increases to the point where it's feasible to run a class of 28 kids on computers.

The problems do not end there, however.

> ... there would be a possibility of us, I suppose, using the computer lab except that that thing is so heavily booked that there's no way you can take a class down there and saying okay, as a class we're going down there and doing this two dimensional simulation on the computer because the day that you wanted to go down there, say, and do that as a simulation lab ... it's being used by Business Ed and the Math people, and so on. They have courses which they are teaching using the microcomputers.

Some teachers have made an effort to bring computers to the science classroom from another area.

> The biggest problems? One was access to computers. It would have been nice to take the class down to the computer rather than take a computer down to the class. And that was about the biggest problem of all....

Teachers' willingness to do this for an extended period of time may be affected by their perception of school priorities. Many teachers have sufficient commitment to have purchased their own machines. If commitment at the administrative level is not forthcoming, their willingness to put out extra effort fades.

> Well, by the time the Grades VIII's and IX's were finished, I'd had it because of the hassle of packing my own machine back and forth and Dr. Petruk's back and forth. And, so I felt about that time that I would like to put a little pressure on our administration of this local school because after all, If we're going to get machines, that's where it would have to come from. ...That's right, they're willing to let me lug them, and so, therefore,...I sat down and I thought, well now just a minute here, hold on. If we're going to be committed to this program, we're going to have to put some money where our mouth is. So then I tossed it in the lap of the administration who endeavored

> to keep their program alive by trying to borrow some machines from other schools. Sort of on a swap basis. But the other schools were, I'd say, smart. They realized that that was a dead end, and really if we ... are committed to that program, we should be putting some money into it. Buying some more machines. And so - no, they weren't even able to ... loan two machines from anywhere which rather boggled my mind in a way.

Teachers look for, and seem to expect to see signs of commitment from administrators, boards, and government. At the same time, this implementation may be different. One principal put it this way:

> But you see I think a lot of those innovations, the push came from the central administration. For example, the overheads (and I remember them coming in) came from Nick Spillios at that time. TV monitors came from central office .... That's not been the case with computers. The initiative for computers has come from the schools, and it could be the school based budgeting that's done that. And, you know, the money is in the schools available to use at the discretion of the staff. We say principal, but that's not altogether correct. So, the initiative - ... I know that there are schools that have got 15-20 computers. And the initiative for the purchase of that amount of equipment has come from ... within the school. The consequence of the whole thing is ... I can't see a central group downtown saying "Hey, this is the way to go, fellas, come on; here's one as an incentive" sort of thing. But ... it'll have to develop maybe in reverse order to what normally happens, because ... if we were to have, say, another dozen computers, I can see us going to the schoolboard and saying, "Hey, we've got those machines; we need help." And that help will have to come, whatever department.... But just the way that it's developed, it's ... developed in reverse order, so the ... push didn't come from downtown. It's an interesting phenomenon because it's ... quite the reverse of what normally happens.

Science teacher commitment has certainly been high to this point. A surprisingly large number of science teachers have invested in computers of their own. This might serve to increase their own computer literacy but is not likely to

have much effect on the classroom in the short term. Teacher access to the computer is a problem in some schools.

> I know ... some high schools do have them in their own department, at least one machine, but this is a pretty small school and we won't, moneywise I don't think its here.

The school in question has at least fifteen computers located in other areas.

Some schools, interested in maximizing exposure, have either set up a central computer facility not tied to any instructional area, or have made the machines portable.

> We only have the two and we've insisted on them being portable this year, so that staff who want to become a little more familiar can in fact do that. We have deliberately avoided tying them in - into an area or into a program for this year. So XXX, for example, has ... a computer club that he runs morning, noon and after school kind of thing, and he's got a small introductory unit, I believe tied into the Grade IX program.... So one is ... in the shop on a fairly regular basis, and the other is available to anybody who wants to use it. For example, during Christmas break, both of them went out into the homes of teachers. And ... that was ... alright by me ... because it was giving them the time that they would otherwise not get.

The question of machine availability is, of course tied to the teacher's view of the appropriate mode of use in the classroom. Many teachers seem to view large scale CAI activity in class groups as the ideal model. It is unclear how such activity could be integrated into a teacher-paced, group instructional format, however. In one school, a conversation with an industrial arts teacher and a science teacher went like this. The researcher had asked if having only two machines was a problem:

> I.A. teacher:

No, because the whole lab is set up like that. The multiple activity approach that I'm using has only ... 2 darkroom enlargers, we've got 2 cameras.... I only have two kids on the machines at once anyway. At the most there's 4 kids in the computing area and it's perfect for that. ....You know if you have other activities set up it would be okay. A person could sit down and spend some time on the computer and then go on to the other activities.

Science Teacher:

It has to be a multiple activity set up unless you've got a class set of computers.

Researcher:

And in terms of the science program, I guess that doesn't happen very much?

Science Teacher:

Oh no!

Next to machine availability, lack of appropriate courseware in the subject area (generally called software by teachers) is the major problem. If packaged CAI programs are viewed as the appropriate use, of course, then the two problems intertwine.

If we had beautiful software that was available to do this with and that would fit our curriculum, and so on, we would have a much better case for getting ... the hardware. But it's kind of hard to ask for the hardware when you don't have the software.

More than half of the respondents specifically mentioned software availability as a serious problem. The perception is that much of the available material is barely usable let alone appropriate.

Teacher:

I would suggest we are very limited. I have ... some biology materials, very few applicable chemistry materials.

Another teacher:

> So we're standing still right now, I think, in the implementation of the computer for CAI material primarily because of the limitation of reasonable software.

And another:

> ... I asked for a copy of everything she had there relating to high school, and she sent me the paper in a very thin envelope ...

One teacher disagrees:

> I think, I know I have more software than anybody else in the public system. They don't have any money.... I guess that's everybody's problem.

It should be noted that the researcher has not confirmed this claim, however. It was not clear that any substantial use, other than some math drill and practice, was actually occuring in this classroom.

Another teacher indicated that courseware production is picking up. He indicated that he had about two thousand dollars worth of material in for evaluation, but it is mainly drill and practice.

> A year ago I would have said you could have bought everything worth while buying for $100 because most of it was really junky stuff.

Cataloging and evaluation appear to be a major problem. Evaluation is rendered particularly difficult because copyright infringement is very common. At least two of the teachers have "bit copying" routines, that is, programs which allow them to copy "locked" disks. Because courseware producers are aware of this practice, demo, loan or preview arrangements are largely non-existent.

> Well I first of all would like to find some programs

> that would fit .. with my Science program, to see what the program is like to see how I could use it. And I'm still in the process of looking for them because ..., they don't let you preview any of these disks. You have to buy them ahead of time. And I don't want to go out and buy something and bring it back and it's totally useless as an educational tool for me.

Teachers generally seem to feel that they are getting little help in this area.

> ... well he had the MECC stuff, eh, and he was going to evaluate it and see what we could use. That's as far as it went. I've never seen the stuff. It never quite got here.... Its still being evaluated up at the top somewhere. Who's doing the evaluating or where it is I don't know.

A teacher was asked about the information flow from the board.

> Well, nothing. The only information I have obtained is from xxx and only because I have called him up and asked. It would be nice if they ... would send out some information so ... we would know where there is some software available or even evaluations on certain software or something like that, but this isn't [his] ball at all.

Another teacher sees it this way:

> I think they're in the same sort of situation as we are. Everyone's kind of groping. And, I think there's a lot of good ideas if we kind of get them together and so on. You know, people, different people have different ideas ... Nobody has the answer at this stage.... Even the Department of Ed., you know, I think is kind of sitting back, waiting to see what's developing out in the field, you know. Somebody down south has kind of developed a software, hardware type of approach and, you name it, it's there.

and another:

> No, I'm sure it's there.... The only involvement we've had was.... approval of professional development funding. Computer literacy is part of our professional development program.... But they haven't brought anyone out to help us.

and another:

> Well, I think [his] main job has been introducing people to the computer and ... he really hasn't had any kind of opportunity at all to come round and help people who are ... moving along. I mean, he's at the bottom helping people just get started into all of these things.... As I perceive it, he doesn't have any time to spend with the people who are trying to do new things with the computer.

Informal networks have become the main source of information.

> So I'm still finding out people.... Again, I wish I had more time like an extra spare or something because ... I use up whatever time I have phoning people to get all the information I possibly can and, you know, one person gives you a name of someone else and...it's the great find .... Hopefully, by the beginning of next year, I'll have everything gathered that I need to know.

Several specific groups of teachers have been identified as participants in these networks. The networks cross system boundaries, although substantial contact between the protestant and Catholic jurisdictions has not been identified at the school level.

The software availability and quality problem raises a number of other issues. One issue is the teacher role with respect to software development. Purchasing commercial software is one alternative to massive software preparation effort. Such purchasing is probably necessary if direct instruction is to occur on any scale in the near future. Because the suppliers of this material try to circumvent "software piracy", however, knowledgeable teachers cannot correct deficiencies in the product, or adapt it to their own instructional circumstances.

> The locker shows you what they are locking. It doesn't really unlock it. The locksmith ... takes about 30 minutes to copy ... a fairly long program, and it does it line by line.... The biggest problem is fixing the little bugs... and when they have you buy a program in 3/2 and how are you going to muffin it?

("Muffining" refers to a method of converting an old Apple disk format using 13 sectored disk to new format 16 sectored disk. The current generation of Apple systems expects a 16 sectored format to be used, but some of the available software, including distributions from educational clearinghouse operations, is still 13 sector).

Another problem related to copying of disks is the question of a "class set". Some recent educational software is available in which the first copy is perhaps $60 but additional copies for use in the same school are only $10 each. Such arrangements have not been the norm with high quality material.

Other approaches are possible.

> One of the problems with sharing is it's illegal... It's copyright material. So somebody has to pay for the system to have this material spread ... Somewhere the money has to come from. So say for this many kilobytes, we'll buy the rights and we can make as many copies - such as Red Deer ... is doing with MECC. MECC is all the way throughout the Red Deer School Division.

Teachers tend to have a very pragmatic attitude toward evaluating materials, given the constraints.

> ... sometimes we have to in the field make a decision that says if we don't look around we won't see it and won't know if it's any good or not. And although we may not use it, and therefore we may not really deprive any royalty money coming through, at some point we have to say, is this worthwhile or

> not. And so I think that one of the, I hope, objectives that will be realized by the microcomputer specialist council if not realized by the content specialist councils will be some sort of strain of objective evaluation of this whole [area].

Some teachers are fully prepared to write their own material, material which could be shared or traded.

> I think it would be better, though if you had teachers who were programmers. No question. Then you set up your objectives and say this is what I want the computer to ask them, this is how I want it asked, and this is how I want it answered.

The knowledge required to successfully produce good material is probably underestimated, however. The next teacher has some interesting material that he has developed. He also has senior level training in computing science and graduate level training in computers in education:

> I basically look at compiler theory being an important aspect of making intelligent programs. I can show you some of the stuff I actually do have - I have some in the partial development stage right now which has limited intelligence in it. But I think for myself at least, I'd be very happy if the board gave me say a period a day or whatever over the course of the year so we could sit down and develop some programs.

Release time specifically for this kind of activity does not seem to be available in any of the systems visited. Possibly because central coordination and specific release time is not available, teachers view materials as proprietory and distribution is limited.

> I have no intention of giving this to the other people in the [area] for free...We have the class timetabling program which...is just a super program... I can do Vic Comp's marks and I can do all of their scheduling... on the Apple.... I just love that one. And they're going to use it in the high school next year, but they'll have to buy their own copy.... We trade among ourselves...

Other teachers take a very different view of their role.

> Well, I think it, when I say "Figure out a way of using", that includes writing a program if I need to. When I say "Figuring ... using them", I mean I want to use them in my classroom. I've got to find something to use in my classroom. That means either I'm going to go and write something for them if I can and I would have to sit down and think an awful lot just about what ... area I'm going to write something on and as I say with my expertise in it, I would be very hard pressed to ... write something. ...Am I a programmer?....

Data collected during this phase of the study strongly suggests that, from the teachers' point of view, board and government activities to this point have been largely ineffectual. Teachers perceive board support as waning:

> His budget was cut down to practically nothing. ... Enough to support himself, I think, and not enough even to continue the pilot projects that were started last year. [Have you any idea why that occured?] ...According to him, I believe it was the tight budget situation, which is very, very disappointing because if you're, if you're really trying to bring computers into the school, you have to start providing information to people.

Whether justifiable or not, unsolicited criticism of government involvement was frequent. One principal put it this way:

> We're going to have to provide something, either as a continuation of what's happening in the elementary or as an introduction before they move to high school. ...I'd like to see Mr. King come out and say okay, at the Grade VII level there should be 15 computers per class, or 1 computer for 30 students, or whatever the case may be. ...provide some funding or at least some encouragement. They came out with this deal ... which is absolutely ridiculous. You can walk into any shop and buy those apples. ...That to me is sick; it's really no encouragement whatsoever.

From a teacher:

> Therefore, we came to realize that the onus is on us. We have got to somewhere get that money out of our budget. There is no money allocated by the school board for microcomputers in the junior high schools, or by the province, ironically enough. Especially when [the Minister] makes the statement that so many million dollars is being put into machines. But where are they sitting? They are sitting in the School Book Branch because someone somewhere booboed. Did not check out his information thoroughly enough. And so it is a little bit annoying from that angle. The Department of Education says, "sure, we're into it", but really, they're not: they're not really committing money to the program - extra money. They're using - I feel - using a political ploy here, because what they have in fact done is not really put one cent into the machines because these machines sitting down at the school book branch did not cost them really anything provided that the school buys them at the cost they're asking for them. Because we can go down to Computerland and buy them cheaper than we can buy them at the School Book Branch. So has the government really put any money into computers? No, they haven't, but they said they have, so it's a neat political move. I don't want to get into politics but it sure makes me furious when ... our Minister of Education says "We're committing so many million dollars to computer education in the province by making these computers available". And so the public thinks where ... is all this money going. Well really, they haven't committed one cent as far as I'm concerned. Unless they got ripped off by Bell and Howell, which could be the case.

And from another:

> I'd like to get the dinner that he was invited out on - get the money from that!

And from another teacher:

> What do you think about the province with their black Apples? I went out and bought one drive for $504.00 last week. What's the province selling it for? ... I would think 6 or more. They helped me a lot, didn't they? I was depending on some kind of help. They blew me out of the water.... What were they thinking of? Tell me, I'd like to know.

Whether teacher perceptions of government support play a large part in spurring school and teacher involvement is

unclear. One teacher who withdrew his personal machine from the school was also a strong critic of government support in this area.

Teachers appear to be watching closely possible government moves in the courseware area.

> Thiessen is concerned with the technology, and my understanding is that the software is being farmed out to ACCESS. Now, I don't know ... what the relationship is going to be between Jim's office and Russ's office.

One area of concern to the researcher, on the basis of previous research on computer use in schools, was hardware reliability. Smith and Pohland (1974) and House (1974) have both indicated hardware reliability as a problem in applying computer technology in teaching. None of the respondents in the current study reported hardware reliability as a problem. Breakdowns have been infrequent and local service was generally described as very good.

> The stuff, basically, is almost idiotproof. Like, I have to do periodic maintenance, like I had the machine out for a day to get the keyboard contacts all cleaned out. And that's about it. I can't really say I've ever had a major breakdown for weeks on end at all.

> I go straight to [supplier]. They're very reliable.

5.2.2 Summary of Inhibiting Factors

1. The most serious problem from the point of view of most science teachers appears to be lack of adequate machine numbers. This problem appears partly organizational, in that the computers in many schools are controlled by other departments, most frequently business education

and industrial arts. They are heavily booked for classes in computer literacy, computing science, and data processing. Fitting in occasional use in science instruction is not perceived as possible or satisfactory. Most science teachers indicated a preference for sufficient numbers of machines to allow full class computer assisted instruction, although there were exceptions to this general case.

2. The second most serious problem indicated was the lack of quality courseware. This issue is a complex one with many facets.

First, the cost of purchased software is substantial. Because copies can easily be made, producers of software do not send it "on-approval". At this stage there is no effective clearing-house function occurring, even though massive review activities are underway if judged across the entire area. Lack of coordination of this effort and the virtual non-existence of a system wide information flow has been a serious problem. Schools cannot afford to purchase software simply in order to evaluate it.

If the courseware does not exactly fit with the teacher's interpretation of the curriculum it is likely to be rejected. This problem does not occur with a book, or even with a film, because, in the teacher centered mode, the teacher can override the message with one of his own. One teacher noted that he can switch off a

projector in order to re-interpret a section for students. In the student-computer interaction, the teacher no longer has the same degree of control. As a consequence, teachers are more demanding of the content embodied in the courseware. The problem is compounded by the practice of "locking" courseware to make it difficult to copy.

The interviews would suggest that, while "locking" is only partly succesful in preventing unauthorized copying, it is almost completely successful in preventing changes to the content of the programs. As a consequence, teachers often cannot adapt material to their "teacher specific" curriculum.

The alternative, which would be the production of large quantities of courseware by teachers, seems highly unlikely, unless there is a major restructuring of responsibilities. The preparation of instructional material is very time consuming. Few teachers receive any release time for such development work. In addition, no formal mechanisms are perceived which could disseminate the results of such development within or between systems. In addition, some teachers questioned whether the expectation of teacher developed software was appropriate. Teachers are trained for a very different role than that of programmers.

3. The last major problem is the perception that boards and governments are not doing very much to help, either in

alleviating machine shortages, in developing and evaluating software, or in providing information and training at the local level. These agencies are seen as encouraging active involvement but contributing very little at the school level to assist the implementation.

5.2.3 Summary of Sustaining Factors

1. Most teachers indicated that their own school administrations have been very supportive. The availability of school funds for equipment and software purchase is an important aspect in continuing the current momentum. Although specific release time for computer activity is not common, the extra efforts of teachers involved with microcomputers seems to be recognized at the administrative level. One teacher indicated that his activity had greatly increased his chances of a sabbatical leave.
2. Additional teacher support is provided by a fairly strong informal network of teachers involved with the technology. This extends across school boundaries and district boundaries. Frequent references were made to the help of teachers in other schools. Also, during the course of the study, a new specialist council was formed by the Alberta Teachers Association. This seems likely to be a focal point for classroom teachers, few of whom seem involved with the Alberta Society for Computers in Education.

3. Teachers report high student interest in all aspects of microcomputing. This student interest is a major sustaining factor on the part of teachers.
4. Teachers who had been involved with microcomputers for more than the current year reported an upsurge of new courseware. There is a feeling that the courseware problem will be solved with time. In the interim, the ability to copy substantial numbers of programs, primarily for evalution, is a major mechanism by which this process is continued.
5. Teachers seem comfortable with the machines. Few report any difficulties learning the basics of operation, and the equipment is reported to be very reliable. It should be noted here that much of the equipment is relatively new and a higher failure rate may be evident as it ages. Service support is currently not seen as a problem.

Chapter 6

STUDENT PERCEPTIONS

The intent of this part of the study was to get some indication of student response to computer based education and of problems of implementation from the students' point of view. The students involved in the study were all taking initial familiarization classes in which they were learning to program the microcomputer using the BASIC language.

6.1 Sites for the study

Two schools were used to obtain the data for this part of the study. The junior high school had been involved with microcomputers for at least three years. Ten computers were available in a self-contained classroom setting. The senior high school used was a large composite high school in a commercial/residential area of the city. For the purpose of the general science module which formed part of this study, three computers were brought from the main computer rooms to the science classroom each day. The students were drawn from non-academic general science program.

6.2 Method

The research method used has been described in some detail in chapter 3. A summary is provided here. Nine groups of three students each were selected by the teacher for the interviews. Four groups, two all boys and two all girls, were drawn from a grade seven math class. Two groups, one of

boys and one of girls, were drawn from a grade nine math class. The last three groups, two of boys and one of girls, were drawn from a grade eleven general science class. The interviews were held in a quiet room and the interviews were taped. The interview guide is contained in appendix B.

6.3 Results and Discussion

The interviews were intended to get student opinion on a number of issues. The first of these was simply the question of their affective reaction toward use of the computer. It should be noted that for most students this was the first course or course segment using computers, and as such, the novelty effect can be expected to be evident, particularly in the case of the grade 11 students, who have had a comparatively short exposure of approximately one month. At the same time, as a group, the general science students might be expected to show somewhat lower interest toward academic learning activities.

Questions were asked directly concerning "liking" to work with computers, as well as satifaction with access to the computer and voluntary usage patterns.

All twelve of the grade seven students indicated that they would like more time on the computer. Eight of these indicated some use outside class hours. Pressure on the facility appears substantial. It should be noted that "game playing" is not allowed except for ones written by the students themselves. The programming of games is the main

activity for students at this point in their learning.

i: What do you like best?

s1: Playing the game once you're done programming it.

s2: Your not allowed to play too many games.

i: Do you like learning to program?

all: Yeah. It's neat.

i: How often can you use the computer?

s1: Five days a week if you can get there after school.

s2: Some days everybody's there and you can't get a computer ... there's usually just enough and three or four people left over.

(note that there are about ten machines available in the school) There is some indication of sex bias operating. None of the grade seven girls indicated regular use after hours, or detailed knowledge of availability.

i: How often do you get to use them?

s1,s2: Once a week...

i: Is that enough time from your point of view?

all: No.

s1: We all feel that we would like more. There's just not enough time.

i: Do you get any other time on them?

s2: There's a computer club. I think you can join that at the beginning of the year.

s1: I know that sometimes during the lunch or after school people are allowed if they get permission to come and just work with them.

i: But none of you do that?

all: No.

i: Is it just all boys?

s2: No, it's mixed.

Computer access was frequently cited as a problem, particularly for the grade sevens. This appears to be the case partly because the grade nine students get a certain amount of priority. Particularly there is competition for the machines with more memory capacity installed.

i: What do you like least?

s1: Probably the crowded conditions.

others: Yeah. Yeah.

s2: Sometimes when the grade 9's come, they kick you off the good computers....

s3: You have to rush like crazy to get one.

s2: And then they kick you off when you get there anyway.

The competitive approach to machine access may be a part of the sex difference in usage. There also appears to be differences in learning approach. The first group of boys interviewed was asked:

i: What do you like least?

s1: Taking notes

s2: The lecture and the notes.

i: How else would you learn.

s1: Get it out of the books...

s2: We've got about 2 file cabinets full of books.

i: You'd rather ...

s3: ...read it than get a lecture.

s2: There are a lot of people who really know a lot about it now ... and you ask them questions and they give you the answers, and basically you remember it.

The first group of girls gave a similar initial reaction.

i: What do you like least?

all: The notes. Taking the notes.

s1: You just sort of want to go and work at the computers, but of course you've got to learn different things...

i: How else do you learn?

s1: Yeah that's ...

s2: Well, you have somebody who knows how to do the computer, and they just sit there with you and work on the computer without taking any notes.

i: You mean like another student?

s2: Well, even a teacher ... but that's pretty hard to do that when there's a class of twenty-five. It would take a while.

When they were asked what else they could do for help, they initiated a short discussion of programming the computer to teach students how to program. They were then asked:

i: Do you have any reference material, manuals and that kind of thing?

all: No. No. We just have our notes.

i: So you don't have books that tell you how to do the

things.

all: no.

Then the next group of boys was interviewed.

i: How do you learn what you need to know to program?

s1: He gives us a BASIC language computer course but then, like, I go buy books ....

s2: You learn from other peoples' programs...

s3: I learn from books. They've got a whole bunch of books that you can look at.

The last group of girls appeared more heterogeneous than the previous three. To the question of liking to work with computers they replied:

s1: They're pretty fun.

s2: Yeah, I think they're okay, sort of.

s3: (to others) They get sort of boring after a while, don't they?

s1: (in answer to s3) It depends what you're doing. After a discussion of programming and games, s3 said:

s3: Basically that's the thing that appeals to me right now, because you're playing games, and the programming, you don't have to do any of the programming or go through all the hassle ... I mean it's interesting to learn how to do it but at the same time you get really frustrated when you don't know how to program the computer...

i: What do you do when you get into a problem?

s3: Usually go to ... the teacher or something.

s2: When you get it wrong you usually just clear the screen.

I don't know how to fix it.

s1: Or you trace or see where things might have gone wrong ....

i: Where do you get most of your information?

all: From [the teacher].

s1: We take notes ...

S1, who appeared much more interested in computing than the others, had apparently gone in on occasion after school. However:

s1: I was interested in it from my older brother because the school loaned us one computer for a summer and neither of my brothers taught me how to do it. So I went in a couple of times but I wasn't taught right off from the beginning .... People just fed me little bits of information so I thought I'd better wait until [the teacher] taught us everything ....

The difference in learning styles indicated here between the grade seven boys and the grade seven girls was rather striking. It appears that the boys, who participate after school as well as in class, have access to a large number of reference books and depend heavily on these plus peer interaction to satisfy the bulk of their learning needs. The girls, on the other hand, give no indication of even being aware that reference books might be available. The desire for a more structured approach indicated in the last quote may be more informative.

The question of use of reference materials was pursued with the two grade nine groups. Only one of the boys was really very interested in the work. He indicated some use of books from which he took sample games. The grade nine girls were aware of the manuals, but indicated that they didn't use them much. They appeared to rely on the teacher and, to a considerable extent, on other pupils.

s: You learn from each other when you're doing computers ....

The grade eleven situation was somewhat different, in that voluntary usage does not appear to have been, or at least to have been perceived as an option for the grade eleven students. Three computers were brought to the science room for the science period and then returned immediately after. There was some indication, on visiting the room where the computers were normally kept, that security is an issue. When the investigator visited the computer area the access door from the corridor was locked from the inside. There was a regular computer education class in session. The Apple computers, which were the ones used for the science module, were not in use at all at the time. They are located in an attached room which appeared to have been designed for storage. This room is not separately accessible from the corridor.

It also appeared that general reference material was not really available, nor, given the limited access and scope of material covered, necessary. Students mentioned

lecture notes and handouts as sources of information. It was evident from all three groups that machine time/access was a very difficult point. At the same time, the six boys indicated a different reaction than the three girls interviewed, both in their approach to access and the positive nature of the experience.

The first group of boys was asked:

i: How did you find it?

s1: (positive tone) It was alright. I didn't mind it at all. It was interesting actually. I didn't mind doing it.

(this student scored 80% on the test)

i: How about you?

s2,3: Pretty interesting. I agree.

They all indicated the waiting as a negative part of the experience, and that they would have liked a lot more time on the machines.

When the group of girls was asked:

i: Do you like working with them?

s1: They're ok, but you have to write tests about them.

s2: You have to remember all that stuff. There's too much to remember...

i: How about you?

s3: The same. Well I don't think we worked on it that long... there wasn't that many computers either, we had to share...

s1: ... three in a class of thirty ...

And later in the conversation:

s1: I kind of think it's a waste of time because three weeks isn't very long. You can't learn that much ...

s2: It would be better to take a whole course about computers ...

i: I guess one question would be ... having had the experience of three weeks, if there was a complete course, a one year course, would you be interested in doing it?

s1: Yeah, ... if you didn't have it related to the amount of computers and stuff...

This comment drew general agreement from the others.

The last group of boys reacted quite differently:

i: How did you like it?

s1: Good, good.

s2: Excellent.

all: Good, ok.

s3: It was fun, especially the games.

When asked what they liked least, one replied:

s1: Nuthin, nuthin, it was good....

All indicated they would be interested in a full year course.

s2: As long as it didn't get too complicated...

s3: I'm going to take computer ed. next semester ...

Thus the general pattern of more positive response by the boys continued to hold.

Yet across the grades, it was the girls in the various groups who tended to justify the work on the basis of its' potential value in the workplace. These are some of the

girls' comments:

s: I like it cause you learn a little bit more about other things ... because if it's going to be in our future anyway, like a lot of people say that later our future will be having a lot more computers, so you think it is educational too, its not just fun.

s: It's become almost a necessity to learn how to use computers, or it will be, not now.

s: You really have to know how to work with computers, for the future.

i: You mean in terms of jobs?

s: Jobs, yeah.

The general finding, then, is a fairly high level of enjoyment on the part of students, with some frustration as a consequence of machine access and also a certain resentment of time spent in lecture and note taking activity. Fewer than twenty percent of the students indicated any kind of disinterest or boredom with the work on the computers, though note taking, typing, and waiting for machines to become available were frequently cited as negative aspects of the task.

An attempt was made to determine the aspects of the task which particularly appealed to the students. The relationship to computer games was frequently a strong motivator, as was the fact that it represented a break from their normal school activities, but a number of other interesting comments were made:

s: What I like, is there is so much that you can do with them....

i: ... the learning to program is a fun experience ...?

s1: Yeah, to make them work, to make them do what you want them to do.

s2: More fun than math class...

s1: They're fun to work with. ... Well you can sort of talk to the computer. You know, how it answers back?

s2: It's fun to get... to make the computer do things that you wanted them to do. Like you never would think they'd be able to do that.

s1: Yeah.

i: That they'd be able to or that you'd be able to..?

s2: Yeah. Well you'd be able to put it in there.

i: And make it do what you want. It sort of demystifies it ..?

s1: Maybe you're in power ...

s2: Yeah.

i: You have the power to control it?

all: Yeah.

From the grade eleven general science students came the following:

i: What do you like best about using them?

s: I dunno. Writing the programs and watching it work, that's about the best part. Getting them to work. Working for a couple of days on them [the programs] and then putting them in the computer and they work

i: Anything else you really like about it?

s1: We can do it...

s2: Seeing how your picture came out..

s3: It's a challenge...

i: What do you think you learn, ...

s1: You find that you could do something once in a while ...

s2: ... how hard it would be really to learn how to work a computer ...

i: You mean by saying "you learn you can learn something", you found out that you could make this thing do some things and that surprised you?

s1: I thought it would be harder, because - computers! Like the name just comes at ya ...

s3: You just think of computers as really hard to do ...

The sense of personal accomplishment and even the beginnings of mastery over what students view as a powerful technology are clearly perceived as a very valuable lesson. This tends to confirm suggestions made by Papert (1980) on the value of teaching students to program.

On the other hand, many educators have viewed the computer as a potential tool for instruction. Considerable research has been carried out. Reviews such as the one by Vinsonhaler and Bass (1972) have long since established the viability of such instructional methods. Such usage, however, can be viewed as an alternative to, a replacement for, the classroom teacher. There may be substantial grounds for concern. At the same time, an assumption that such use

would necessarily dehumanize a system which is currently effective and humane seems, to this author, to oversimplyfy the issue. Thus this issue was raised with the students on the basis of their experience of computers (and quite considerable experience with conventional classroom practices). It should be emphasized at the outset that these students had little experience, if any, with direct instruction utilizing the computer, and are reacting, therefore, more to their perceptions of possibilities than on the basis of firsthand knowledge. Their comments are, none-the-less informative.

On the subject of how to learn to program the computer, one student volunteered:

i: What else could you do?

s1: Well, maybe somebody could program the computer, because I've seen computers where you turn them on and they gave you orders ... and you just go on and do it that way and it works.

i: You mean in the sense of actually having the computer teach you how to program it?

s1: Yeah. I've seen that done before. Like I've used a computer that's done it.

Later in the same group the researcher asked:

i: You haven't actually had any computers that teach you how to do other things?

all: no.

i: What do you think that would be like?

s1: (enthusiastic) I think that would be neat!

s2: That would be fun. I've seen it on TV once, on the news how they worked. Computers were teaching kids math, and stuff like that. (enthusiastic) I wouldn't mind doing that.... They were saying how computers are taking kids away from their teachers. ...so (pause) that's good.

i: Do you think that's good?

s1: Well, it's good in a sense.

Student s1 in the next group has actually been writing a drill program in science terms. When asked if they would like using the computer to learn other subjects, the conversation went like this:

s1: Like the program I'm writing? Would it be better on the computer or with a science teacher?

s2: It would be better on the computer

s1: Why would it be better on the computer.

s2: Because you can ask the computer the questions.

s1: Yeah, but say you don't understand something the computer is telling you? The computer ... may have the answer, but you can't ask, see, the computer asks you the question. You give it the answer, but if you ask it a question it's not going to give you the answer.

At this point there was a joking discussion of the difficulty of asking questions of one of their teachers, punctuated by one student role playing the teacher with "Shaddup". They went on to discuss pro's and con's of what amounted to computer assisted testing in the language arts

area.

s2: It is better with the computer than with the teacher, because the teacher is teaching you, but the computer is teaching you how to type and how to get the question right.

s1: Yeah but you could go ... through one question and ... through one hundred answers and get them all wrong and you may never get the right answer. At least the teacher will tell you the answer after at least three of them.

s3: You could program it ... You could program it after the third time to tell you the right answer.

It is interesting that not all authors of commercially available instructional material take advantage of the simple instructional strategy these grade seven students devised in three minutes of conversation. The topic was raised with the next group of girls:

s1: My brother had something like that. but I've never had that happen to me. He's in grade 2, so he's using computers quite early, but he's not programming or anything. It's just things like math and spelling.

i: But you haven't used anything like that. Do you think that it would be a good thing?

s1: You mean better than being taught to read or math by a teacher as compared to the computer?

s: Yeah.

s2: It wouldn't be that bad...

s1: I suppose though, if you ran into difficulties you wouldn't be asking the computer, because if you didn't know

how to ask the computer, there'd be that difficulty. You'd probably have to go ask the teacher.

s2: It'd be funner.

s3: Yeah, it would be funner than all those teachers blabbing all the time... It would!

i: Why would that be? I mean what would be more fun about it?

s3: It would be interesting, no maybe more ... lets say ... a... difficulter.

s1: Well, yeah, but that would only be so far as the person who put in those words as notes ...

s2: Well, maybe the teacher would program the computer and the computer would tell like all the kids. And I think it would be more funner. You'd probably learn a lot faster.

i: You think you'd learn faster?

s1: You'd certainly pay more attention because you've got this screen to yourself and there aren't, like the teacher ... everybody else has to look at the teacher, and there are so many other side attractions. I mean they're already at the computer and everybody else is looking at a computer as well, so it's not as distracting.

i: Ok. So you figure in that kind of circumstance you would actually be able to go faster just because you were concentrating?

s1: ... You'd probably be able to proceed at your own level.

i: Would you want to do that every day?

s1: Well, you've got to put up with the good, the bad, and

the ugly, that sort of thing, but ... I guess you have to put up with some things in order to learn more about others. I don't know. How would you guys put it?

s2,3: I dunno.

In the discussion with the grade eleven girls, the question of computer based instruction drew the following comments:

i: What do you think that would be like as a way of learning?

s1: It would be more interesting...

all: [general agreement]

i: Why do you say that? I'm not disagreeing with you. I'm just wondering why you think it would be more interesting.

s3: Well you wouldn't be sitting in a class ...

s2: It wouldn't be so boring ...

s3: ...listening all the time...

i: So it is the fact that you're doing something and sort of interacting with this thing rather than sitting soaking up knowledge ...

s1: ...Which you're going to forget anyway.

s3: That's the main thing in learning. Sometimes teachers make it really boring and you don't want to learn ... its so boring that, you know, "forget about this..."

These students clearly feel, on the basis of their current experience, that there is potential in the computer as an instructional tool. Just how much of their apparent enthusiasm is a reaction to what they perceive as less than

fully satisfactory learning environments in the teacher centered classroom is unclear from this study. It does suggest, however, that humanistic concerns must focus on other than a simple condemnation of technology.

6.4 Conclusions

The evidence gathered from this part of the study clearly indicates a positive learning experience for the majority of the students involved, as well as a positive attitude on their part toward use of the computer in the school. This must be seen as occurring in spite of difficult environmental considerations concerning access time and number of machines available. There is a further indication that teachers are handicapped in terms of appropriate instructional resources for use with students. Those students who seem the most advanced in term of their knowledge of computing make use of available reference manuals, but there is a heavy dependency by most students on lecture notes.

The contribution to student self-concept is, to this researcher, one of the most positive gains apparent from these programs. From the content point of view, however, the value of the activity is unclear. First, there does not appear to be a common definition of what constitutes computer literacy accepted at the classroom level. In the classrooms utilized in this study the emphasis was entirely on learning to write simple programs in the BASIC language.

Second, there is not a close link to the discipline area under which the units were offered, either apparent on review or perceived by the students.

In the following chapter some comparisons will be made between student and teacher perceptions of the microcomputer phenomena in order to better understand the current implementation.

Chapter 7

DETAILED SITE VISITS

Following the preliminary site visits described in chapter 5, and the student surveys described in chapter 6, a more intensive study of six sites was carried out involving visits, discussions and interviews in six selected schools. In total, some thirty-two additional site visits were made between May, 1982 and February, 1983. These involved both informal observations and discussions with teachers and administrators. In addition, a sub-set of teachers reacted to documents prepared by the researcher which were designed to assess their positions with respect to the direction of further computer use in the schools. Reaction was obtained both by completion of written documents and by a series of taped discussions.

The individual sites have been described in a series of case statements which are included in appendix C. The first draft of each of these statements was verified with the participating teachers in order to confirm the researcher's perception of the situation in the schools.

7.1 The Degree of Implementation

Over all it is safe to say that at this stage the computer is having minimal impact on the teaching of the traditional sciences in the study schools. In two of the schools some substantial progress has been made in the teaching of computer programming and computing science as a

discipline within the science department. In the other four schools, this activity has gone to other departments largely, in the opinion of the researcher, by default.

7.1.1 Administrative Uses

Across the six schools, the one common usage appears to be class records management. This activity seems to have been widely adopted for four reasons.

1. The demand for physical computing resources is minimal. A single machine and printer, housed in the department office or in a staff area can serve a large department with minimal conflict.
2. Several commercial and teacher written packages are available which conform to teacher expectations and require minimal teacher competency in using the equipment.
3. The use of this teacher resource requires no conceptual shift on the part of teachers with respect to the way they operate their classrooms. On the contrary, these administrative aids reinforce conventional patterns of classroom organization and activity.
4. Teachers believe improved organization and record keeping contributes positively to their teaching performance.

One school uses the computer extensively for word processing of tests. This facilitates the preparation of alternative forms and the improvement of questions through the

development of a large bank of teacher generated items. The word processor is used to assemble these into test forms.

7.1.2 Instructional Uses

None of the six schools involved in the detailed site survey made substantial use of the computer for direct natural science instruction over the course of the study. Two high schools and one junior high school reported class use of an instructional package in chemistry, but these uses amounted to only about one period of actual student contact.

Scheduling of computer lab time is a problem. In all schools the computer labs are booked for about seven out of eight periods per day. No school in the group has been able to set aside a substantial number of machines which are not heavily booked for computer literacy / computer programming courses. At the junior high level, neither of the two case study schools received substantial additions to their complement of machines. Budget cutbacks were cited as one reason for this. It appears to this researcher that an additional factor may be an attempt by boards to equalize the distribution of computer hardware, particularly by expanding into the elementary school level. In one district, for example, the junior high received one extra machine while several machines have appeared in local elementary schools.

The area of computer software for instruction appears to be changing rapidly. One teacher complained that whereas

he had little to choose from last year, the list of available software this year is overwhelming. As yet, no mechanism for evaluation of software has had any noticeable effect at the school level.

Neither board nor provincial efforts have resulted in usable information in the schools. The establishment, during the course of the study, of an office within the Department of Education to address this task may in time alleviate a portion of the problem.

Even given recommendations with respect to software purchase, few schools have adequate budgets for substantial acquisitions. Only one of the six case schools reports large holdings of software, and usage there is minimal due to machine shortages. Most schools have budgeted in the neighborhood of $500 for the year for software. One major package could easily absorb this entire budget.

The magnitude of the organizational problem, although seldom directly addressed by teachers, is probably the greatest impediment to further instructional use, however. To utilize any substantial amount of computer based teaching/learning activity would require a major restructuring of classrooms. In the researcher's opinion, this is a major factor detering further implementation.

If one attempts to assess the current level of the implementation in terms of the Concerns-Based Adoption Model (CBAM) proposed by Hall and Loucks (1978)), the majority of teachers involved in this study would have to be considered

at the "personal", and "management" level. Those involved in the study demonstrated an overall commitment to the innovation that would place them well above the "informational" level. Several indications of concern for the teacher role in decision making and for potential organizational conflicts were raised. This was particularly the case in schools B and D where there was apparent political conflict over control of direction and control of resources.

The "management" level of the Hall and Loucks model was represented in this particular innovation by concerns for courseware and machine availability. There seemed an implicit assumption that if these problems were solved then a satisfactory level of implementation would occur. Precisely what represented a satisfactory level clearly differed from teacher to teacher. On the basis of the models of usage proposed in the last section, however, it would appear that the majority of teachers do not anticipate major structural changes in the process of schooling as a consequence of computers.

Only two of the teachers involved focused substantially on the question of consequences for students. Both were in terms of relevance of the activities of their students. It is perhaps significant that both have been directly involved in teaching computer literacy, and that their direct personal involvement with computers spans three or more years. In this context a concern with relevance was

represented mainly by a conviction that some minimal exposure to computer programming is important for most students through to a concern that the programming represent "good" practice in the field of computing science.

The research plan called for an attempt to conceptualize a humanistic model of computer use through "delphi-like" interaction with the teachers. This tended to raise issues of "consequence" and "refocusing" which represent the latter stages of the Concerns Based Adoption Model. Teacher response to this portion of the study might also be useful, therefore, in determining teacher positioning with respect to the Hall and Loucks model.

7.2 A Model of Computer Use -The Teacher's View

In chapter three a process was described in which selected teachers reacted to two successive sets of position statements which dealt with humanistic issues in the use of computers. The first set of six statements were drawn primarily from transcripts of teachers' comments recorded during the preliminary site visits (see appendix D). The statements selected were quite controversial and open ended. Three dealt with the concepts of individualization, socialization and the nature of the school as an institution. Two questions dealt with the human contact issue: student/teacher versus student/machine. The last statement dealt with the computer as teacher versus the computer as tool.

7.2.1 The Procedure

The statements were distributed to nine teachers in five schools. The teachers were given about two weeks to consider their reactions to the statements. The researcher then collected the marked documents and also taped eight interview sessions. The tapes were converted to about forty-two pages of transcripts.

The transcripts were evaluated and a more detailed and specific set of eighteen position statements prepared. This set is also found in appendix D. For this iteration the teachers were asked to respond in writing, indicating primarily if they agreed or disagreed with each statement. Ten teachers responded to the statements.

7.2.2 The Results

In order to better understand the teachers' positions, the results will be examined in detail.

Statement #1

> In the long term, substantial changes may occur in the organization of learning for children. While there will be much greater use of computers and other technological devices to enhance learning in the home, the bulk of formal learning activity will still occur in school settings.

Eight out of ten teachers agreed with this statement. Comments included:

> "very desirable."

"Communication between teacher and student is imperative. It would be foolish to remove the exchange of ideas, the socialization and the practical learning which occur in the school setting."

"I think that learning should be a social exercise and a socializing exercise. From an economic perspective we may see technology take over, but from a socio-personal perspective I am leery."

"The 'school' could simply be the data centre. Access would be multivaried and each learner would learn from his school-console in the study room."

"These [schools] may not be as envisioned today but in a somewhat specialized setting i.e. a computer centre."

"I hope less will occur in the schools, but what happens will depend on societal attitudes."

Statement #2

In the extreme case, the school setting may provide primarily the socialization aspects of learning with activities such as physical education, crafts, arts and band being the main vehicles. Children would attend perhaps one or two days per week.

Only three teachers agreed with this statement as even an extreme scenario. Comments ranged from:

"I think less formal time in a 'school setting' would be more humane."

and

"this appears to be one logical extension of computerization of learning. The student yet requires the opportunity to be initiator in the learning process."

through to

"Every classroom and school activity is a socializing exercise. There is more and more evidence that even scientific facts are socially constructed - the social process is important in all

subjects.

> "Socialization aspects of learning will have to be part of academic studies as well - more than two days a week is necessary."

and

> "Too much time away from the school setting would increase the 'hanging out' element and would not ensure a learning process taking place in the home. Too much emphasis would be put on self-motivation."

and finally

> "I can not see the school administration and the parents allowing this. There are too many working mothers and educational jobs dependent on day to day attendance."

Statement 3#

> It seems more likely, however, that what will occur will be a greatly increased use of computers in the school both for direct teaching, and as a tool for student word processing, checking lab results, and the like.

Two respondents disagreed. One felt that this would be only a short term situation:

> "Short term - yes / Primitive application. Long term - debatable / You would have to assume a more sophisticated application.

The other teacher did not comment, but it was clear from his other responses that he felt increased usage of the computer to be neither desirable nor likely.

From those eight who felt comfortable with the prediction came the following:

> "Word processing, checking lab results and modeling and simulations extend the type of learning, not just the quantity."

"There has already been a tremendous increase in the use of computers over the past 2 years (eg. right now about 5% of students in grades 10-11 are using word processing programs; about 20% can program to some degree) - two years ago only a small handful could program."

"This may well even spill over into homes which can afford computers."

Statement #4

This is a preferred scenario because the socialization that occurs in school is an extremely important part of total school learning. Students learn to interact with others, and, in addition they learn the "content" of the disciplines by absorbing or selecting from other students' ideas.

Eight respondents agreed with this statement.

"And [to] learn that content, even at the highest levels, involves social constructions."

"They may also learn 'content' from good courseware."

However, on learning to interact with others:

"This is a skill a computer cannot teach."

As to the preference for this scenario, one teacher noted:

"Perhaps more so during the formative years than at the high school level."

One respondent clearly disagreed. To the question of socialization as an extremely important part of school learning, he replied:

"Today - not necessarily tomorrow."

On selecting from other students' ideas:

"[There is] no reason why programming can not provide this alternative idea package."

The last respondent stated that this was really an area which needed research.

Statement #5

> What is necessary is to strike a balance between direct learning from interaction with the computer and learning by involvement with the teacher and with others.

The same respondent indicated this also as an area for research. The other nine agreed with the statement. Clearly:

> "The issue remains - just what is that balance. If one is meant to interact with the machine 90% of the time then _; if 50% then _; if 20% then _."

> "... it may take time to extablish the balance. It may even be different for each individual."

One emphasized the curricular aspect. He called for:

> "An integrated (vs. segregated) balance. Computer modeling (or at least the use thereof) should be part of a course, not a course unto itself.

Statement #6

> Isolation in the home could lead to lessened tolerance and acceptance of others' ideas, needs and desires and even to antisocial behavior. Contact in a school-like setting is an essential aspect of childrens' development. Childrens' feelings of self-worth, their recognition of "self" is largely developed by feedback from this group environment.

Eight respondents agreed:

> "A very important aspect of the total overall growth of an individual."

One felt this was:

"... extremely so at the elementary levels."

A third noted that:

> "A few students don't look to the group for this feedback (at least not openly), but seem to get great satisfaction from successfully tackling something in the computer field."

The two dissenters were rather adamant:

> "Pure specualation. The evidence is not in. The evidence would probably show that the family situation would be even more important (i.e. 2 working parents would be even worse.)"

> "[In the] present context, not fururistic.... [there is an] assumption [that] the school operates at a higher info/social centre [sic] than the home. Is that, in fact, fact?"

Statement #7

With increased use of the computers, there will be an even greater reliance on others for the exchange of ideas, reassurance and assessment of one's own worth and purpose.

There was a lower level of agreement on this issue than on the preceeding ones. Six agreed generally. One teacher noted:

> "...not necessarily a reliance for exchange of ideas, but reassurance and own worth would be important."

Reacting perhaps to the current generation of computer literate students, one teacher noted:

> "We have to guard against some students not believing that exchange of ideas with mere mortals is important."

The strongest dissenter again challenged the assumption that these activities necessarily occur as a consequence of

schooling:

> "[The] exchange of ideas is not equal to reassurance, and assessment of one's worth and purpose. [An] info bank is not equal to a process model."

One teacher again saw this as an area requiring research:

Statement #8

The group setting does not hinder the development of individuals provided the numbers in the class are in the 20-25 range. Below 15 it is difficult to achieve the degree of interaction which is desirable.

Support for this statement was rather evenly split. Teachers noted as factors the ability, age, social level and type of activity. Two commented that group interaction with smaller numbers was not really a problem. One suggested:

> "Current evidence from academic classrooms seems to support this statement, but academic students are well trained seals anyway and adapt as required."

Significantly, no one focused on the question of individuality. All of the comments implied concern with the interaction level.

Statement #9

By use in a remedial mode, the computer can help weaker students keep pace. Complete self pacing is not a desirable goal.

Seven teachers indicated general agreement with this statement.

> "The student needs to be motivated and complete self pacing may deter advancement if self-motivation is lacking."

> "[There is] some need for pacing as required."

> "In many cases exposure to major ideas is more important than self-pacing. Self-pacing is important to drill material, but not to exposure to major ideas."

Two teachers agreed with the potential value of the computer to help weaker students keep pace, but felt complete self-pacing could be a desirable goal.

> "In certain areas self pacing is desirable (eg. in music or for gifted students). Certainly the computer can help weaker students keep pace in courses where this may be necessary."

> "Self pacing is what many strive for. Therefore it can be a desirable goal. The HB pencil can provide the means."

Statement 10

> In addition, the current level of courseware (software) development renders self pacing impractical.

Seven agreed. Some saw this as the way things should be:

> "Self-pacing should be integrated into a classroom experience and will therefore only ever be partial and never totally satisfactory due to varying classroom situations."

Some expressed the opinion that this was a temporary problem.

> "Short term only. If self pace [sic] is found to be desirable the software will follow quickly."

> "A lot remains to be done in developing courseware for classroom use. Even PLATO at U of A is incomplete at present but a start has been achieved."

> "Programmers must be taught how to write educational software."

One teacher noted that programs such as Millican Math

provide for self-pacing now. One teacher shifted the focus from the courseware to the internal motivation issue:

> "Not necessarily so. Self-pacing is more dependent on the interaction between student and teacher as well as parents and peers.

Statement #11

> In the tutorial skill learning or remedial mode the best organization would be to have one student to one computer.

On the question of machine resources and organization eight agreed a one to one situation would be best.

> "Whenever two people use one terminal, one of them will establish the pace."

> "... this is idealistic and probably impractical ($) [sic]."

Two teachers expressed concerns that this arrangement would negate socialization. One suggestion was one student to one computer:

> "But with 2 or 3 students to 2 or 3 computers side by side."

Statement 12

> For all other types of computer activities there should be at least three students per machine. Individual "carrels" such as are typically used in language labs should be avoided.

Only two respondents expressed agreement. One of these might, in the authors observance, prefer at least five-hundred students per computer. Two others suggested two students to one computer would be preferred. One suggested the multi-student multi-machine "group carrel" would still

be preferred. Two saw little value in the group approach:

> "individuals should be able to use a computer one-on-one for word processing and indepth individual studies. - currently we seldom put 3 students per book in any activity.

Statement #13

While students are using computers, the teacher role will be supportive in the sense of supplying positive feedback to the students, but also tutorial in the sense of correcting deficiencies in the courseware, elaborating on concepts, and the like.

All ten respondents agreed with this statement. However:

> "Unfortunately the teacher will initially spend too much time forcing things to work. The teacher should be providing the contexts for the learning (i.e., the epistemology and social significance).

With respect to correcting deficiencies in courseware, one teacher queried:

> "Can most people do this?"

Statement #14

This role will be more demanding of the teacher than the traditional role in the lecture situation. It will, however, closely parallel current teacher activity in laboratory settings.

Nine of the ten teachers believe the role will be more demanding than required in the lecture situation.

> "The trend is to individualization and computers would be an asset to this trend."

> "The extra demand will be in making "poor" labs work. But I don't see the demise of the lecture, just the change in content of the lecture."

"only time will tell for sure"

Statement #15

Access to computers will be very widespread. Students will spend about 50% of their school time engaged in computer activities, but not usually for longer than one hour at a time.

Most respondents agreed that access would be widespread, but several felt an estimate of 50% of time engaged in computer activity was high.

"I think that 50% is too high. Possibly as high as 30% would be more desirable."

"50% computer time seems high -- I am unsure."

"50%? My future forecasting isn't that accurate."

"50% is too much time for most important topics. Perhaps 50% will be indirectly related to the computer (e.g., doing a lab checked by computer)."

Some of the teachers indicated a one-hour per session maximum was too arbitrary.

"Depends on the students ability and interest and the type of program he/she is working on."

"could be more or less (I've spent 4-6 hours on some activities)".

"...different subject areas will have different approaches and may require 1 hour, less or more than 1 hour depending on whether the computer is used for concept review, problem solving or introductions to a concept. 1 hour is too arbitrary at HS level."

but

"care will have to be taken so that students are not subjected to many consecutive lessons on a computer terminal."

One teacher questioned the organizational assumptions, suggesting the possibility of an open-ended school day and

multiple shifts.

"There is no magic in 8 am to 3 pm."

Statement #16

The computer is only a tool, not unlike other media currently used in teaching. Although students show great enthusiasm for computers at present, the novelty will soon wear off and at that point they will be treated in the same way as books, film, TV and the like.

In terms of overall agreement, this question was the most divisive. Some view the computer as a super (or not so super) media:

"...although the potential for usefulness may be greater than other media."

Some feel that the quality of the courseware is the key issue:

"[I am] unsure - If originality is used in software development then the novelty will not wear off. Courseware in this form can be less static if teachers can program."

"[disagree] unless the programs available and limitations of the computer are such so as to do this."

"The novelty will wear off to a certain degree. However, a balance between computers, books, film, TV etc. as well as verbalization, writing skills and practical skills will be the ideal learning process. The computer learning process is so new and untapped that the novelty will be perpetuated as the field expands. The automobile was considered a novelty in some respects. it is now a way of life. Computers will become a way of life in a similar fashion."

"[The] car was a novelty when first introduced but our dependence on it has changed dramatically. With time computer dependence will grow to [the] same extent as hand calculators and cars, more as we

learn its powers."

"Computers will become serious tools -but always fascinating. If students get to operate the computer directly -- as a lab-like activity versus a demo activity, the enthusiasm will remain fairly high."

A different set of metaphysical assumptions may underlie this reaction:

"Hawthorne effect? Nyet! The machine is key. Learn the key and advance. Ignore it at your peril."

Statement #17

Learning to program the computer, while worthwhile for perhaps 10% of students, is likely to be less valuable than using the computer for tutorial teaching, lab simulations, and the like.

Six teachers agreed with this concept, although some thought the 10% figure was low.

"I strongly agree (as a science teacher). As a math teacher I would probably see value in developing logic through programming."

"Basic literacy is important, but the need for programming [is] not."

"10% is low for learning to program in a useful way."

"[I disagree with the] percentage as it implies equality with IQ distribution. 10% may be too low but certainly 100% is too high. Can one equate percentage to IQ distribution? Debatable"

The minority view programming as a useful skill for most if not all students, as a valuable activity in its own right, having a different focus from tutorial and simulation activities.

"I feel that everyone should learn how to program the computer."

"we currently teach students to write, as well as read - a parallel exists with computers."

Statement #18

These kind of activities can be integrated easily into the existing school structure if sufficient machines and courseware (software) packages are available.

Six respondents agreed with this statement, while citing as determinants such factors as suitable staff training, capital costs for hardware and software, space, and administration. One called for machines and courseware to be:

"...made available through a conscious deployment of dollars - choice not default."

One noted that integration would be easy:

"...as long as traditional methods are not hindered."

The dissenters commented:

"Integration is never easy. Compartmentalizing is easy. Integration is going to require extra work and hopefully more than just economic and pedagogic efficiency will be considered as evaluative criteria."

"[This] ...requires a complete reorganization of school structure".

7.2.3 Discussion of the Results

The data gathered during this phase of the study tends to confirm the earlier assessment that the majority of teachers are at the "personal" and "management" levels of the CBAM model. This is inferred by the rather

"conservative" views of the respondents with respect to the probable changes which might be brought about through the use of computers in the school. If one compares the teacher response to the predictions and suggestions of authors such as Stotler (1970), Toffler (1981), Godfrey (1980), and Evans (1979), the magnitude of the difference in views is remarkable. Since the teachers represented by this study are those already in some sense committed to and involved in the computer implementation they must be considered as in the vanguard of the movement.

Significantly, the more extreme view of the future came consistently from those who had at least three years experience with computers. There are two reasons the researcher can advance. Either those with a more radical view of the future gravitated toward computers at an earlier date, or the longer exposure has opened horizons to them which they had not previously considered. Both possibilities are tenable and remain unanswered in this thesis.

Implicit in positions with respect to socialization within the school versus socialization outside the school seems to be a notion that the current conventional classroom is highly effective in positive socialization. There is, however, some research to suggest that teacher perceptions of classroom environments and student perceptions of the same environment can differ substantially (cf. Fisher and Fraser, 1983; Gay, 1976). One can also question the unstated assumption that the home environment will remain

substantially unchanged. Toffler's (1981) electronic cottage would represent a very different socializing environment from current homes with two working parents. Teachers never raised the issue of the role which two-way data communication might play in such an environment. On the other hand, the danger of "familial isolationism" (Evans, 1979) must be considered as very real.

The issue, from the point of view of the current implementation, is that widespread adoption of forms of computer use by classroom teachers could conceivably occur with minimal structural change. This appears to be the preference for the majority of respondents.

Another interesting issue raised by this study is the question of student-student interaction in the teacher centered classroom versus the interaction in a computer environment. The student interviews brought forth such comments as:

> "You learn from each other when you're doing computers..."
>
> "There are a lot of people who really know a lot about it now ... and you ask them questions and they give you the answers, and basically you remember it."

These comments suggest a high level of peer interaction, directed toward common problem solving. While this would seem to be a positive form of socialization, it should be noted that some of the related instances occurred in loosely supervised activities outside of regular class hours. In addition, the most skilled experts in such groups are often

students, not teachers. This fact may alter the social dynamics of the situation.

One teacher reported that on short term exposure to instructional courseware there was very little student-student interaction. He attributed this to the novelty aspect, since it was the students' first exposure to the medium. It is interesting to recall the student suggestion that there would be fewer distractions in a computer-based instructional environment than would be present in a teacher centered one.

It would seem, to the author, that the environment created in a CAI classroom could have important ramifications, both for academic and for social learning. At this early stage of the implementation there has been little opportunity for teachers to experiment with alternatives. The suggestion made by one teacher of small clusters of three or four students to three or four computers was not observed in use in any of the schools visited.

While socialization was viewed as an important issue, individualization was much less so. Having last been involved in research in the schools in the early 1970's when attention to "individualized programs" was at a peak, the author found the attitude rather surprising. Considerable emphasis on group activity was evident in the discussions. This may be viewed as reflecting the reality of the courseware and hardware situation in some cases. An alternative explanation is that the difficulties associated

with managing individualized activities, whether computer-based or not, are sufficient to dissuade teachers from serious attempts to integrate individualized materials into their classroom activities. A second alternative is that a "refocusing" (Hall and Loucks, 1978) has yet to occur for the majority of the teachers. As a consequence, little thought has been given to "universal benefits" or "major changes".

Chapter 8

SYNTHESIS, CONCLUSIONS, AND RECOMMENDATIONS

Futurists have predicted major changes in the structure of education as a consequence of the rapid development of microcomputers and their expansion into the business place, the school, and the home. Some suggest that the school, locked into traditional patterns of action, will be unable to adapt to the educational opportunities of the information society. Godfrey (1980) is more optimistic:

> "The educational system at the present is a Carrier whose Content is the accepted and valued knowledge of the society. It is place-bound, time-bound and unused to competition or innovation. No other sector of society is more vulnerable to the new technologies. I will predict, however, that within the system (after an initial period of protest), terror will become the mother of adaptation, and although the formal structures will continue to shrink as the work week shortens, creative teachers will have tasks and opportunities that they had previously never considered possible."

This chapter summarizes the findings of the current study on the state of the local computer implementation in science education and the processes through which adaptations are occurring.

8.1 Current State of the Implementation

A basic assumption of this research is that the early stage of the implementation of microcomputers in the school may be important in terms of the initial directions. This research is an attempt to understand and describe the process of implementation of microcomputers in science education in the local area in the early stages of activity.

That the implementation of microcomputers for science teaching is at an extremely early stage was confirmed at all levels of the research model. In understanding this statement in the context of this study it is very important to differentiate between science teaching and science teacher involvement with the implementation process. Sixty percent of schools contacted in the 1983 survey (Chapter 4) reported science teacher involvement with the microcomputer implementation. This represented a one-third increase from the previous year. Thirty percent reported some use in science instruction, up from twenty percent in the previous year. Thus science teachers are actively involved in the implementation process, but actual science instructional hours utilizing a computer are very low. Schools which formed a part of the detailed site study had minimal software or courseware for student use in science. In addition, access to computer hardware was very limited within the science departments.

8.2 Participants in the Implementation

Teachers and students appear to be the most important participants at this stage of the implementation. Board personnel and government personnel appear to have had minimal influence, although board sponsored inservice activity has raised the level of awareness regarding microcomputers.

Principals appear to have played a support role in responding to teacher, student and parental pressures. Machines have been provided, often from school based budgets, and teachers have been encouraged and praised for their individual activities. Principals generally seem well versed in the pattern of utilization activities within their schools, although some tendency to overstate activity levels was noted.

8.3 Major Determinants of the Implementation

Factors which were identified during the study as reinforcing and sustaining the implementation are as follows:

1. Student interest in access to computers has been high. This in turn has encouraged teacher interest.
2. A range of involvement mechanisms have resulted in substantial numbers of teachers showing interest in microcomputers. These mechanisms include such things as previous computer experience and/or training, contact with colleagues, and contact with computers in the home environment. External pressures from parents and students as well as heightened public awareness have played a role. Least frequently cited as an involvement mechanism was administrative pressure to become involved.
3. Local school administrations have been largely supportive in providing equipment, in-service

opportunities, and recognition of achievment on the part of their teachers.

4. Strong informal support networks have grown up involving teachers both within schools and between schools. These networks have served as a source of information and assistance in all jurisdictions.
5. Teachers have found it possible to adapt the technology to various useful roles, particularly to administrative roles. Those involved in the study have not experienced serious difficulty interacting with the technology.
6. Teachers believe that there will be a rapid increase in the availability of good science instructional material for the computer over the next few years.
7. The hardware has been reliable and maintenance has not been a serious problem to this point. This is particularly relevant in that previous studies of hardware intensive implementations have reported hardware reliability as one of the more serious problems.

The main problem areas in the implementation which were identified in the current study are as follows:

1. The number of machines available for student use is still very small. As a consequence, both student and teacher access is restricted. The physical placement of the computers is also an impediment to widespread access in some instances.
2. There is a lack of courseware and of information about

courseware and software in the area schools. Schools have little money to purchase courseware and other software and adequate mechanisms for review and evaluation of available materials are not yet in evidence.

3. Commercially available computer based instructional materials are difficult or impossible to modify for purposes of adapting to local curriculum needs. This makes the evaluation problem even more serious.
4. Teachers have insufficient time to evaluate software or to engage in preparation and programming of their own materials.
5. There is little assistance available in the form of either materials or personnel for those teachers who have progressed beyond the lower levels of involvement with and understanding of computers.

8.4 Characteristics of the Implementation as Process

Fullan and Park (1981) list twelve factors which they describe as affecting implementation. Their classifications are useful in examining the current implementation. At the same time this implementation deviates substantially from the view of implementation as commonly presented in the literature. These deviations will be examined in the context of the model presented by Fullan and Park.

It should be noted that their approach to the implementation problem appears primarily formulated to

address the implementation of curriculum change, where curriculum is understood to mean the content and the teaching of content. Such implementation generally is a consequence of changes in a provincial curriculum guideline. At the same time they state: "The ideas in this booklet are applicable to any kind of curriculum or policy change in education" (Fullan and Park, 1981). On the basis of the current research, some additions and revisions to their model seem warranted to make it more universally descriptive.

8.4.1 Characteristics of the Innovation

Fullan and Park identify three characteristics of the innovation or revision in their table of twelve factors.

1. Need for the change
2. Clarity, complexity of the change
3. Quality and availability of materials

It is particularly at the level of innovation characteristics that the implementation of a technology may deviate from the implementation of a curriculum guideline.

8.4.1.1 Need for the Change

The first characteristic of an innovation which Fullan and Park have identified is "need for the change". One might argue that it is at the fundamental level of "need" that the implementation of microcomputers in the schools is unwarranted - that they represent "solutions in search of problems". That the

computer is seen variously as a solution to many different problems is a unique characteristic of the current implementation. Depending on ones' perspective, the computer is seen as a way to individualize and to self-pace or as a way to remediate and to lock-step. It is seen as a way to replace traditional science labs and as a way to enhance traditional science labs. It is seen as replacing teachers with more cost-effective hardware or as totally dependent on the presence of well trained teachers to be of any value at all.

"Need" is very much a subjective judgement. It is a unique characteristic of the computer that is is theoretically capable of conforming to any of these "need" expectations. This is not to suggest that the environments so created would be at all similar - only that the flexibility of the machine allows it to be adapted to widely differing tasks as has been clearly demonstrated in other contexts. Thus in this implementation, the characteristic which Fullan and Park describe as "need" is replaced with the concept of "invention", whereby the technology is adapted to satisfy quite different needs on the parts of the various practitioners. Such a change in the model would substantially alter our understanding of the necessary action required on the part of participants.

8.4.1.2 Clarity and Complexity

The clarity/complexity factor is similarly unique. There is no clearly defined and prespecified pattern for computer use in the schools. A pilot literacy program is only now being introduced at the upper elementary level (Blair, 1983). Little guidance is available as to the appropriateness of specific courseware. Teachers have had minimal pre-service or inservice training in the content or the use of computers.

Teachers and students can be seen to interact with the computer on a number of different levels. Nearly all of the science teachers involved in the study have mastered to some level a small but usable piece of the technology which they have been able to adapt to their own situation. This ranges from the use of marks records through word-processing to programming in machine language.

It would appear, then, that the great flexibility of the medium is in a very real sense partly compensating for lack of clarity. Teachers who are already involved feel comfortable with their approach and perceive it as appropriate for their circumstances. Fullan and Park (1981) point out that a given implementation may involve more "...than people perceive or realize." This can result in a "false clarity". Supporting this notion is the fact that six teachers out of ten viewed the implementation as essentially

non-problematic, given sufficient numbers of machines and adequate courseware.

There is not an immediate need to face this issue in the secondary school. Change is occurring slowly, restrained by the large capital outlays required. Since computing devices have entered all levels of the school system virtually simultaneously, however, the senior high schools can be expected to be under rapidly increasing pressure as larger and larger numbers of computer literate students enter from the elementary and junior high levels. This phenomenon will require a very fluid approach to curricula about computers - i.e. computer literacy and computing science.

The results of this study suggest that teachers do not perceive substantial changes occurring in science instruction as a consequence of widespread computer use. Because the computer can respond individually, however, and can teach learning skills such as reading as well as the content of disciplines such as chemistry or physics, it has the potential to magnify or to minimize individual differences, depending on how it is ultimately utilized. If, in fact, there is a "false clarity" on the part of teachers concerning the application of this technology this may have serious consequences at further stages in the implementation.

8.4.1.3 Quality and Availability of Materials

The third factor in the Fullan and Park model is "quality and availability of materials". This factor has been identified as a major impediment in the implementation which is the focus of this study. The magnitude of the problem in this particular instance is clearly unique. In the "curricular-guidelines-implementation" instance, materials normally precede any attempt at widescale implementation. Hardware is generally not an issue with the possible exception of special lab equipment in some science curricula. Where written materials have had to be produced locally, high speed duplicating has been able to satisfy the quantity if not the quality problem. In the implementation of a hardware dependent innovation the quality/availability factor takes on a different meaning which requires further subdivision. The following areas of concern are apparent from the current study:

1. Availability of hardware - equipment must be available in sufficient quantity to allow all participants adequate access with minimal serious disruption of normal scheduling of classroom activity.
2. Suitability of hardware - an attempt must be made to match appropriate hardware with the uses to which it will be applied. In the computer instance this is a very complicated issue. There are hundreds of makes

and models of computer - most incompatible in one or more ways with other makes. In some instances several models made by one manufacturer may have serious incompatibilities with each other. Individual teachers and schools are currently ill equipped to make fully informed decisions on these issues.

3. Reliability of hardware - This has been a problem in previous technological implementations, and should be a serious consideration in any planning associated with such implementation. The current study did not identify reliability as a problem area at this point in time.

4. Availability of information on hardware and its operation - The provision of this type of information to schools is important in sustaining activity and aiding system selection. Particularly in schools attempting more innovative applications of the technology, detailed information is required. In the current implementation there does not seem to be a source of such information easily accessible to the schools other than that provided by computer dealers.

5. Availability of Software and Courseware - This factor is the most similar to the usual problem of curriculum implementation identified by Fullan and Park (1981) as "quality and availability of

materials". This issue has been discussed and documented elsewhere in this thesis. For the purpose of elaboration of the implementation model, however, the focus is on the process. In the "curriculum-as-guideline" case, one is dealing with a pre-selection of appropriate content resources to enhance or replace existing materials. In the technological implementation, the requirement is for a more continuous and ongoing activity including both selection and revision. In addition, new issues of compatibility with equipment, problems of duplication of software, and problems of modification of software, come to the fore.

6. Availability of information on software and courseware - Because of the wide range of materials available, their relatively high cost, and the difficulties of detailed evaluation, new mechanisms are required to provide adequate information to schools. The magnitude of the problem in the current implementation does not appear to have a parallel in the "curriculum-as-guideline" implementaton.

8.4.1.4 Origin of the Innovation

A characteristic of the implementation which is ignored in the Fullan and Park (1981) list of factors is the origin of the innovation. The omission may reflect an assumption that implementation is a process in which centrally derived goal statements are "implemented" by

intervention. An innovator or team of innovators, through planned efforts and activities, brings about a change in teacher practice. Such a description of the implementation process is clearly not appropriate in the current situation. Rather, the current implementation originates primarily at the school level as a set of diffuse and non-systematic "inventions" which become more focussed through experience within the school and contact between schools. The usual "innovative chain" from the department to the board, to the principal, and finally to the teacher, has been supportive. It has in some instances been effective in raising levels of awareness, but the effect on direction of activity has to this point been minimal.

The addition of "origin of the innovation" to the list of characteristics proposed by Fullan and Park (1981) would seem to enrich the concept of implementation both in its own right and through encouraging reflection on the meaning of the other characteristics within the total model.

8.4.2 Characteristics at the School System Level

Fullan and Park identify six factors at the school system level which affect implementation:

1. History of innovative attempts
2. Expectations and training of principals
3. Teacher input and professional development

4. Board and community support
5. Time lines and monitoring
6. Overload

8.4.2.1 History of Innovative Attempts

Fullan and Park point to the past history of implementation within a school system as conditioning how participants feel about new innovations. Since this study involved primarily those who had already manifested interest in the use of computers, a belief in potential change as a consequence of innovation would seem indicated for these participants. At the same time there is an average of fewer than ten teachers per school actively involved according to the data presented in chapter four. There may be various reasons for non-involvement, but a belief that computers will bring about minimal change in the classroom is clearly one major determinant.

Skepticism was found at the administrative level in schools where committed teachers were pressing for more resources. One can infer from the support level provided by the school districts and by the province that there are serious doubts at all levels external to the school as to the value of this phenomenon.

There is a tendency to equate the introduction of microcomputers to the previous introduction of technologies such as educational television. It is clear, however, that microcomputers are already being

introduced into schools and utilized within schools in numbers which exceed the use of television even after nearly thirty years of experience with the television medium. This would suggest a qualitative difference in the microcomputer medium which makes previous history of innovative attempts a factor of minimal importance.

8.4.2.2 Expectation and Training for Principals

Fullan and Park identify the principal as a key participant in implementation and view the expectations and training of principals as very important in enhancing the probability of successful implementation. This may well be true in the top-down curriculum case. The importance of the factor in the current implementation is less clear. In the study schools, the teachers have led the implementation. The principal's role has been facilitative in questioning and approving, rather than guiding. As such, the principal fulfills his role as administrator rather than instructional leader.

Certainly specific skills and understandings on the part of the principal are required to deal with this complex phenomenon. To attempt to determine and to specify them is beyond the scope of this particular study.

8.4.2.3 Teacher Input and Professional Development

Since this implementation appears to be centered in the school, teacher input and control is very

substantial. Interschool cooperation, teacher networks, and most recently the formation of a computer council of the Alberta Teachers' Association have played a support function. In this context the concept of teacher input might be more appropriately replaced by a concept of teacher involvement and sharing - that is, teachers become involved in some "invention" relating to the microcomputer and then they share that invention, either through informal networks or by presentations at professional conferences or seminars.

The boards and more recently the province have begun active programs of inservice. The effects of this activity appear to this researcher to have been minimal to this point, although it has in some instances acted as a "seed" to further activity. Technical assistance at this level, other than introductory inservice, has been virtually non-existent.

8.4.2.4 Board and Community Support

Thus far, boards appear to have been reasonably supportive of teacher initiatives in the microcomputer area. Of equal importance, in the opinion of the researcher, has been the support of professional colleagues. The ATACC may be expected to play a major part as an "advocacy group". House (1979) has suggested such advocacy groups are essential in order for an innovation to succeed. There are others. It is a major reversal of the traditional situation that pressure for

change is coming from the unlikely alliance of parents, students, and teachers. It will require a longer study of the phenomenon to determine if this "alliance" will endure.

8.4.2.5 Time Line and Monitoring

The suggestion of monitoring the process over time at the administrative level is really an RD&D notion rather than an adaptive evolutionary one. The researcher, on early contact with one responsible central office person, was rather intrigued with his analysis of the problem which was stated approximately as follows: "The schools are getting microcomputers for themselves. We have to find a way to control them". A control paradigm is an inappropriate focus in the opinion of the researcher.

Rather, what is required is extended support in the areas of evaluation, and in addressing the " ... overload problem which occurs when teachers are attempting to implement several curricula simultaneously" (Fullan and Park, 1981). In two schools in the preliminary site visits, time conflict (and cost conflict) associated with other new curricular demands were cited as impediments to microcomputer use in science. One district level science supervisor stated: "Microcomputers are not a priority with me".

8.4.3 Characteristics of the School

At the school level Fullan and Park have identified the following factors:

1. Principals' actions
2. Teacher/teacher relations and actions

It is interesting that students and their relations and actions are not considered a part of the implementation process. In the current implementation high student interest and activity levels were identified as a strong motivator for teacher involvement. As such, it would seem that students should be seen as active participants in the implementation process, rather than as passive receptors of a final product.

8.4.3.1 Principals' Actions

Fullan and Park emphasize that principals should play an active role in implementation but not necessarily a directive one. In the current study, the teachers who have become involved at this point have some clear ideas as to their particular needs. Where the principal tends to treat a teacher as the authority, which is true of the majority of schools visited, attitudes appear positive and progress is being made. In those few schools where the implementation is more centralized through extensive involvement of the principal or vice-principal, there seem to be more problems. One tendency is an attempt to get the principal (or vice-principal) to take sides in

territorial disputes. This tends to shift teachers' attention to political rather than instructional concerns. Evaluative focus shifts to concerns of quantity rather than quality.

8.4.3.2 Teacher/Teacher Relations and Actions

The teacher has been the main focus of this study. Fullan and Park state:

> In those school situations where, for whatever reasons, teachers interact with each other on some ongoing basis, implementation is much more likely. When teachers in a school have or create the opportunity to assist each other in addressing and attempting to resolve the many issues raised in the implementation of a significant change in the classroom, change in practice will more likely occur. Implementation, as we have said, involves the development of new teaching approaches and examination of underlying beliefs. Teachers as a group in a school are likely to have the collective ability to help one another acquire many of the skills and understandings associated with a change. Teachers' colleagues are a preferred source of knowledge and skill. One of the greatest obstacles to effective implementation is that teachers do not have the time to interact with each other about their work, and changes therein.

A quite remarkable feature of the computer implementation is the extent of teacher interaction which is apparent. The technical complexity of the hardware and software is one possible reason. Not only students "learn from each other when doing computers". Several schools seem to have well established tutorial networks, often with several distinct teacher specialists - machine language programmers, Apple or PET specialists, word processing specialists and the like.

It seems likely that these networks contribute both through extending interaction and also by providing a strong sense of self-esteem. The novice who discovers a new program that others have not seen is equally valuable and valued in such a network.

The physical restrictions associated with limited machine resources also contribute. Where a machine is housed in a science office it tends to be a focus for small group teacher interaction. Where computers were housed either more publicly (e.g. a general staff room or classroom) or less accessibly, (e.g. a private office or special "computer room") this effect was not observed.

8.4.4 Factors External to the School System

To this point in the implementation the influence of provincial government agencies has been neutral to perhaps slightly negative. Without being judgemental as to the quality of the decision and its implementation, the "Black Apple" controversy caused at least four problems. First, the time taken to make a decision resulted in some dismay in the school system as to which way to proceed. Second, teachers and administrators felt betrayed by the final pricing and implementation of the decision. Third, competitors of the chosen company increased their activity and advertising, and cut their prices. Very large numbers of "non-approved" machines continue to be purchased by schools. Fourth, the

controversy has accentuated staff splits within schools, to the extent that there are "Apple camps" and "Pet camps" which view each other competitively. Perhaps most seriously, the credibility of the government ministry was damaged by the publicity. Whether this will have long term effects is unclear.

Within the local area, the other agency which has had a substantial effect is the University of Alberta. While the University may rightly feel that its role is not at the inservice level, very large numbers of teachers have taken University computer courses since the "micro revolution" began. Some professors from the Faculty of Education have been very much in demand as conference speakers. This activity is having a decided influence on the progress of the implementation. In only about four cases was pre-service education cited as a major determinant of teacher involvement. None of the cases noted involved recent university studies.

A further observation is that the Alberta Society for Computers in Education, which has been quite active for about three years, appears to primarily attract the post-secondary educators. Comparatively few teachers were present at their fall conference. The 1983 spring conference of the ATACC drew over 600 teachers and administrators. From an experience and research point of view the ASCE group has much to contribute to the teachers in the field.

8.5 A Revised Implementation Model

To appropriately characterize the current implementation, a revision to the Fullan and Park (1981) model seems required. It must be reiterated that the Fullan and Park model seems primarily descriptive of implementation of curriculum as a planned activity initiated at the level of a government department. The implementation of microcomputers in science education, however, appears to be more a consequence of adaptation at the classroom level than a result of planned activity. The changes suggested for a revised model would be the following;

1. The concept of "need for the change" is replaced by the concept of "invention", which is a process in which individual participants adopt the technology by adapting it to their individually perceived needs.
2. Availability, suitability and reliability of hardware is a factor in the current implementation and should be included as a factor in the model.
3. Availability of information about both hardware and software is an important factor in the current implementation. A focus on information about materials rather than on selection or production of materials is a substantial alteration to the model which has been presented by Fullan and Park.
4. The origin of the implementation should be a factor in a complete implementation model. Factors such as "need for the change" and "clarity/complexity" have a different

meaning when the ultimate implementor, the classroom teacher, is to a large extent responsible for initiating the implementation.

5. The role relationships of teachers, principals and boards need to be reexamined. Fullan and Park (1981) state:

> "Obviously, the role of the board administrator is crucial. Effective implementation is much more likely when he or she works with system and school staff to put together a comprehensive, broadly endorsed and understood plan for implementation than when implementation is left to the chance of curriculum products, written directions, one-shot workshops, and infrequent meetings."

   This role description is that of an administrator, planner, implementor rather than a facilitator and partner in implementation. In the current implementation, mechanisms for sharing ideas and successes, for increasing the flow of usable information on materials and hardware, and for providing multilevel technical assistance, would seem of more potential value than attempting to synthesize a "comprehensive, broadly endorsed ... plan for implementation".

6. The student must be recognized as an active partner in the implementation process. The student must not be treated as simply a source of statistical measures of curriculum effectiveness.

7. The focus should shift from "teacher input" to teacher involvement and idea sharing.

8.6 Conclusions

If one viewed the current implementation as having the primary objective of replacing teacher centered instruction with CAI, then one could consider most of the current activity as cooptation (McLaughlin, 1976). On the basis of the evidence collected during this research it seems clear, however, that central administrations and government have been largely reactive. An attitude of cautious exploration of alternatives seems evident at the school level and to an extent at the board level. Viewed from a political perspective (House, 1979) any activity in computing is seen to be positive and valuable. School administrations appear very anxious to have their schools seen as in the vanguard of activity. In the absence of external criteria any activity is viewed positively. A perusal of documents at the provincial level (King, 1981; Computer Technology, Vol. 1, No. 1, May 1982; Wighton, 1983) would suggest a somewhat narrower focus, emphasizing content specific CAI. Even at the provincial level, however, there are signs of a broadening focus (cf. Blair, 1983).

At the classroom level teachers are involved with coping. Interest is high, but time and resources are serious constraints. Obstacles to effective classroom use may be underestimated. On the positive side, the diversity of approaches to utilization is encouraging. At this point in the implementation continued invention seems likely. This is in concert with the researchers notion of an "organic

systems model" of implementation which assumes that change in behavior is slow and incremental. Such a model makes considerable sense in a humanistically oriented endeavor. Within this total model an RD&D approach can be applied whenever and wherever the goals of a part of the total implementation can be shown to be unambiguous, internally consistent, and free of serious conflict with goals of the institution as a whole.

Continuous program evaluation and review would provide the necessary feedback to identify strengths and weakness of the implementation. Such evaluations would be seen as formative, used to adjust the approach, rather than as an explicit "go/no go" summative evaluation. Resource allocation is adjusted to favour successful innovations.

This is clearly an evolutionary model having characteristics very akin to the biological model of Darwin. The fit succeed and the unfit die off. It is a cruel model in some ways, but when one recognizes that it is a microcosm of the social system, one realizes that institutions themselves are like biological organisms, and no less susceptible to the laws of succession and evolution.

8.7 Suggestions For Further Research

This study is an attempt to contribute to an understanding of the dynamics involved in the current implementation of microcomputers in the classroom. Although extending over a period of fourteen months, it must be

viewed as a "snapshot" in time. In the context of an implementation which may still be in progress in the twenty-first century, it portrays a very temporary reality. The need for longitudinal naturalistic research remains. A number of general research areas can be identified:

1. Is the prevalent view of computer literacy consistent with the real nature of the field, in terms of concepts and concept hierachies, and what adjustments may be required to be consistent both with the discipline and with childrens' developmental patterns?
2. Are there skills which involve computer use which are transferrable to other discipline areas, in particular to science?
3. Are there ways in which the computer can be used by students to help them understand in a unique way the basic concepts of science?
4. Are there classroom usage modes for the computer which will enhance both content learning and overall development of children as social beings?
5. What additional modes of support are required to assist the classroom teacher in coping with microcomputers? What forms of preservice and inservice training are beneficial?
6. What shifts in teacher perception of the computer in education and its relation to curriculum occur over longer periods of time (three to five years)?

8.8 Closing Statement

The implementation of microcomputers in an educational environment is underway. Although the process must be viewed as a very early stage in terms of its overall effect on science education there are a number of factors contributing to the momentum. Perhaps most important at this point is that students and teachers alike enjoy working with computers and learning about computers. Papert (1980) would explain this phenomenon in terms of epistemology. In exerting our control over the logic of the machine, we examine our own logic processes. Our interactions are both personal and sharable.

Interest also occurs at a quite different level. Teachers would have to be considered among the first "information workers". They predate libraries, census bureaus, and national opinion polls. The technology which has been responsible for the phrase "the information revolution" is now accessible to them. They have no difficulty in visualizing ways of applying computers to their own particular problems. The government and the public at large are currently supportive. It remains for the future to judge the outcome. The environment of the school of the future may take any of several forms. Garson (1980) has proposed some extremes. The one environment which seems unlikely is that in which the computer plays only a minor role.

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APPENDIX A - Some Administrative Documents

This appendix includes annotated excerpts from documents generated within school systems in the study area.

In order to protect the anonymity of the systems and schools which took part in the study the documents are not identified.

Document 1

This was a presentation to a school trustees meeting.

Madam Chairperson, Trustees, Colleagues

Allow me to express my sincere thanks to the Board of Trustees on behalf of the Committee for providing us with the time and opportunity to present this interim report and recommendations on the Utilization of Microcomputers in Education and thus inform you about an exciting and revolutionary technology, which may have as much impact on society and education as did Guttenberg's printing press and Alexander Graham Bell's telephone for communication.

From the outset, the technology is characterized as "revolutionary".

It is my pleasure as coordinator of this committee to introduce all the members who have assisted in the preparation of this document and who will upon completion of

my introductory remarks, discuss uses of computers in their specific areas of expertise.

XXX - Dept. Head of Math/Science, School XXX
Chairman of this Committee

XXX - Math Supervisor, Editor of the Report

XXX - Itinerant Teacher, Gifted Program

XXX - Teacher (Physics, Math), School XXX

XXX - Junior High Teacher, School XXX (also had the pleasure of visiting schools with the Hon. David King)

XXX - Supervisor of Science

XXX - Acting Supervisor, Practical Arts

XXX - Supervisor, Practical Arts

XXX - Consultant, Media Services

The committee is chaired by a teacher, as opposed to an administrator or central office person. Three other teachers are included, one of whom "had the pleasure of visiting schools ..." with the Minister. Teacher visibility is high from the outset and some of the "glory" associated with the innovations is being accorded to them.

This study and report was initiated in response to:

1. the proliferation of different types of microcomputers and computer programs in our schools. (Currently we have

twelve schools with at least one microcomputer at the school and approximately fifteen other schools have responded that they may be purchasing a computer next year.)

2. requests for the funding of projects involving microcomputers
3. requests from teachers and principals for information about computer hardware, software and programming assistance
4. a need for a committee to examine the impact of computers in education.

This report is a reactive response to an implementation already begun at the "grass roots" level.

In all walks of life today man is confronted by a new order of information processing and problem solving that has become a common element of society. The influence of this new technology on our society is increasing even more rapidly and of all technological developments the computer may have the most influence and the inevitability of its existence must be recognized and dealt with.

"...man becomes truly free only insofar as he belongs to the realm of destining and so becomes one who listens and hears, and not one who is simply constrained to obey."

(Heidegger, 1962, translated by Lovitt, 1977)

Computers are now an everyday tool in business, government and industry. They are used in stores, banks, travel networks, weather bureaus, government agencies like STATS Canada, License and Revenue departments, police, hospitals and industry in updating and maintaining records of inventory, personnel, bank or charge balances, exchange, movements in the transportation industry, etc. as well as for problem solving, research and design by the major institutions and businesses. In most school districts computers are commonly used for payroll, accounting, budget, inventory, purchasing, scheduling of students and maintaining student records.

The computer is seen as a tool of business and industry, not of science. (Historically its use in science and engineering predated by almost a decade its serious adoption by business and industry.)

In the midst of a computer revolution which has been changing many aspects of people's daily lives it seems wise to foresee the effects on our system of education. It is safe to predict however, that the present changes in storage, processing and dissemination of information will have effects as great as those brought about by the introduction of printing and they will occur at a much

faster rate.

It is not surprising that people tend to be overwhelmed by the seeming complexities of computers and modern information processing. Nevertheless, we are in a Computer Society and it becomes necessary that members of our society become aware of the impact of computers and that these same members become functionally literate in the language of computers and of the function computers have and may perform. People should be made aware that the computer can be harnessed to work releasing them from the drudgery of the past. Through the illumination of dull, routine work, people can be freed to utilize their inventive abilities and to develop and fulfill themselves creatively.

Garson (1980) has presented this along with less attractive scenarios.

Computers form a hugh industry in their production, in the production of software and in the use of computers. The needs of this industry is providing an occupation for many people. Highly trained personnel at the high school level and at other educational institutes must be developed in computer language, literacy, programming and technical training.

It is significant that to this point the total emphasis has been on computer literacy, ultimately, it would seem,

because of the potential job market which this opens up for graduates.

At this point a short description of computers was provided, most of which as been omitted from this abridged version. However, it concluded with:

A computer is infinitely patient, readily adjusting to different student ability [sic] and becomes a tireless tutor and as [sic] a general purpose and problem solving tool.

Implications of Computers for Education

It is not surprising therefore that as the general market for computers continues to expand, as computers become more economical to purchase, as teacher and administrators become aware of computer applications, and as the majority of our students become exposed to computers, that this technology will have significant implications on the whole educational enterprise - on programs and curriculum, delivery of programs, teaching of students, learning activities of students and on teaching and administering.

1. Curriculum and Programs

One of the functions of the school is to provide the students with skills which will allow them to function effectively as informed, responsible, educated citizens and

as productive workers in an ever increasing [sic] complex adult society. Providing students with some knowledge of what computers are and can do is necessary to meet this goal.

The curriculum in most cases does not reflect the current capabilities of computers or what role computers play in their lives or in the lives of adults in society. The majority of students graduating from our schools are computer illiterate. This means that they have little insight into the capabilities and limitations of computers, or how computers affect their lives. They do not know how to use a computer as a tool for coping with the problems they will encounter or as they continue their education.

The question of what students should learn about computers has been studied by many professional groups over a period of years. There is nearly universal agreement that all students should become computer literate.

Historically, computer literacy tended to refer to only the awareness of computers. However, educators have come to realize that students at all educational levels can learn to use a computer as an aid to problem solving. Computer Assisted learning or instruction provides a relatively painless and inexpensive approach to accomplish part of the computer literacy goal. Moreover studies have indicated that any student use of computers leads to computer awareness and knowledge of computers. Having students develop a useful level of programming requires a substantial amount of

instruction and practice. This indicates the necessity of having access to microcomputers for the "hands-on" experience and preferably the application of computer techniques to problems from other subject areas.

There is no "universal agreement" as to what constitutes computer literacy. The researcher believes computer assisted instruction to be a painful and expensive approach to computer literacy. It is perhaps this thinking which has led to the use of equipment priced at $2500 for tasks which could be accomplished with machines which currently cost $150 to $250 in single quantities.

2. Implications for Students and Instruction

The aim of the classroom teacher in all levels of education is to help each of his/her students reach a satisfactory level of scholastic achievement. To accomplish this a teacher must adapt his classroom instructional activities to meet the needs of the individual student. However, because of the number of students typically enrolled in the class, and because of the wide range of differences in student learning styles, background, and abilities, teachers can seldom provide as much individual instruction and interaction as they would like. This applies in every educational environment from ECS to 12.

One of the most important uses for computers in schools today is to help students receive more individual attention

and instruction - and this can be accomplished by using the computer as a tutor.

An emphasis on individualization as the goal of computer instructional use is evident here. This may be compared with the deemphasis on this aspect by teachers in.the current study.

A short description of and justification for CAI has been omitted. What follows is particularly relevant to the topic of this research.

The most exciting form of computer assisted instruction - which really turns kids on - is simulation. In science, computers can simulate dangerous experiments or experiments for which necessary equipment or skills are lacking. Ecology simulations could allow students to investigate industrial policy decisions in relation to the quality of life; biology experiments that took many years to run in practice can be simulated within a class period; the Physics class can investigate the problems in operating the Three Mile Nuclear power station; population simulations have been developed for the social studies courses; students can compare the movement of objects on an inclined plane in both the real world and one without function, etc.

Canned computer simulations lead students to experiment with these and test their own concepts.

While this may be occurring within the system, the researcher has detected no significant usage of this technique. Nearly two full school years have elapsed since this report was released.

The next section of the report dealt with the computer as administrative support to the teacher. It concluded with:

Computer use promises more effective, efficient and creative use of teacher time and energy. A considerable number of tasks which teachers perform but are necessary are clerical in nature - marking exams, computing marks, preparing and compiling exams, reports and statistics. These functions can be automated and thus allow teachers the time to better plan programs and monitor the learning process. From the point of view of creative energy teachers would rather spend more time with students and plan programs. As the computer takes over more of the clerical and repetitive duties, the role of the teacher becomes more professional. This offers the potential of greater job satisfaction and more efficient use of educational funds in promoting the learning function. The computer offers pre-testing for each module; directs the student to reference and practice materials or to provide remedial help; maintains a complete record of each students' progress and compiles students' profiles on objectives which have been covered.

Current studies by both Alberta Education and Saskatoon Public Schools emphasize computer managed instruction.

The notion of CMI is here presented as arising from traditional teacher clerical tasks. The omission of specific reference to the self-paced environment which is typically associated with CMI could be viewed as significant.

The following sections stressed the adoption of action plans by Britain, France, Germany, Holland and Japan. In addition:

The majority of American schools have computer networks devoted to computer assisted and managed instruction. British Columbia, Saskatchewan and Ontario have led the way in Canada. In Alberta the response and move towards the use of computers is now moving so rapidly that studies like this and others throughout the province, as well as by the Minister of Education, have been initiated to provide for some immediate direction.

There are clearly political reasons for school systems to pursue and to be seen to be pursuing the use of the computer in education.

Teachers and administrators in our system have always shown leadership and innovativeness. The application of computers for educational use is now being effected in some

12 schools with 15 other schools indicating interest and purchase of hardware this year if financial and advisory support were available.

Our committee has already organized an evening inservice for approximately 13 teachers who met voluntarily from 7 to 10:30 p.m. for a period of five consecutive weeks at [a school] under the supervision of [a teacher]. Teachers of Industrial Arts are now voluntarily participating in the same course.

The application of computers in education are many and varied and at this time I would ask different members of this committee, who have expertise in a subject area or level of instruction to indicate to you what is currently being done and what are some future directions.

Should you have any questions of myself or of any of the members of the committee - please feel free to do so.

In a successful implementation, teacher interest and teacher confidence in their ability to cope is important. Inservices assist in disseminating the necessary skills. Voluntary participation outside of working hours is an indicator of strong commitment. It is also significant that a local teacher rather than an outside expert was employed to carry out this work.

In conclusion, allow me to thank the trustees for their kind attention and interest and for making this an

informative and practical experience and to thank my fellow colleague members of the committee for their expertise and assistance.

We in the field of education, must move in the realization that we are not dealing with a passing fad but with a rapidly expanding technology-driven phenomenon.

The acquisition of microcomputers today is as financially viable as was the ownership of motion picture projectors or televisions during their inception.

It is already a fact that many microcomputers representing different brands and different types of software are presently in use in our schools.

Such proliferation, particularly of different types, poses potential problems on two fronts.

Firstly, it appears to perpetrate the very "piece-meal approach" we tend to refer as being undesirable because of maintenance, support and upkeep problems and

Secondly, though the language of programming may be common, the hardware and software of competitive brands is not compatible. The implications for software compatibility are forboding.

The appropriateness of having a carefully monitored system project with some person to coordinate the project and the further acquisition of specific brands of microcomputers by the district is felt to be unquestionable.

The emphasis on the technology-driven phenomena is in the

original.

One could view this passage as advocating an attempt to impose an RD&D model on an implementation "in progress". There are some implicit assumptions which lie behind the "unquestionable" "appropriateness" of the suggested coordinator position. This is not to suggest that the position was or is unwarranted. On the contrary, additional resources are probably required. Some of the assumptions are non-the-less questionable in the opinion of the researcher.

The report concludes:

Because of the positive applications of computers in education as well as for the reasons just mentioned, the following recommendations are placed before you for your consideration.

1. That the Board of Trustees give their full support for the establishment of a pilot project to gain much needed first-hand experience and to provide a basis for professional development (the pilot project would include all of the schools using microcomputers).
2. That a coordinator be appointed to coordinate the implementation and evaluation of the pilot project.
3. That funds be made available for the following purposes:
    a. upgrade equipment

b. purchase software

c. purchase four microcomputers

d. provide inservice to teachers.

Document 2

This document was a draft of a report prepared for another school board within the study area.

Microcomputers in the Classroom

Introduction

There are few who would deny the impact of computers on society today or, indeed, their contributions to it. Records indicate that the first school based computer in North America was installed in 1959 for primarily administrative purposes. Since this time, rapidly advancing computer technology, paralleled by decreasing costs, has greatly aroused the interest of educators who justifiably view its potential with great optimism. The following quotations are typical acknowledgements of the educational potential afforded by computer technology.

> "The recognition of the inevitability and proliferation of computers in society renders it appropriate for educators in the schools to assume a responsibility to impart a degree of computer literacy to their students. Additionally, an attempt should be made to capitalize on the use of the computer as an educational tool."

> "One thing is certain about the technological revolution: educators should not attempt to avoid it, to criticize it in ignorance, and hope that it will go away. It will not. They should grasp it and exploit it to its maximum potential to the end of improving the quality of education for everyone."

A flirtation with the educational application of computers in the [system] occurred as far back as 1968 at

which time, several factors contributed to the lack of its universal acceptance, not the least of which would have been the cost. The rapid technological advances referred to above, however, have led to the advent of the microcomputer, a highly affordable "desk top" computer which, though deceptively insignificant in appearance, possesses the capabilities of a machine which less than twenty years ago would have completely filled the classroom.

Enthusiastic computer related activity currently exists within the [system] some of which is outlined herein.

This document approaches the technology directly. It is significantly different from document one in that it is prepared ostensibly by one individual in central office. It reports on a specific project rather than directly soliciting further support.

Notably absent from the introduction, and from the sections that follow, are specific references, by name, to involved teachers and principals.

<u>The [System] Pilot Project</u>

<u>General</u>

Recognition of the resurgence of interest in, and practical viability of, the educational use of computers led to the requesting (and subsequent granting) of approval to initiate a Microcomputer Pilot Project. Such a project has

been in existence since September 1980 and is thriving in three of the district's schools namely, XXX Elementary, XXX Junior High and XXX Composite High. A total of thirteen microcomputers support the project of which eleven were made available through centrally administered funds. Some major objectives of the project are:

1. The promotion of computer literacy.
2. The promotion of diversity of application (of the microcomputer).
3. The provision of inservice.
4. The appropriation, evaluation and field testing of courseware.
5. The evaluation of computer related instructional methodologies.
6. The evaluation of computer related hardware.

Implicit also has been the establishment and maintenance of contact and liason with other projects and agencies whose influence impacts upon the general area.

The central nature of this project is established. The funding, the goals, and the evaluation is central, in keeping with a traditional RD&D model.

In fulfilling the first three objectives, no less than twenty-three inservices will have been delivered to district staffs by the end of April. Requests for such inservices are being satisfied at the extremely high rate of two per month.

During the same time a further ten formal speaking engagements, and subsequent exchanges of information, have been fulfilled through the project including those sponsored by Alberta Education, the Alberta Teachers' Association and other school districts.

Two, one and a half day introductory inservices have been organized in conjunction with the University of Alberta. These inservices have been designed to acquaint both central and field administrators with microcomputer technology. This inservice activity resulted from a needs assessment survey that was conducted and through which more than one hundred were contacted. The level of interest is such that the number of administrators that have requested participation is twice that which can be physically accommodated.

The focus seems to be on top down design, on dispensing information, particularly to administrators.

A further, more extensive, inservice/workshop directed towards senior school administrators is being considered for implementation in the last two weeks of the summer recess. It is expected that participants in this workshop will acquire rudimentary programming skills.

One can assume that programming in BASIC is a feature of these inservices. Such a focus, particularly with

administrators, clearly indicates some implicit assumptions about the field and the directions of implementation. The assumptions are not really stated in the report.

The report goes on to describe the elementary school project:

Activities at this small school are supported by two microcomputers and a very enthusiastic principal. At the outset, a grade 5/6 class was receiving regular exposure to the microcomputer in support of their studies in math, language arts and, to a degree, computer literacy. Interest has increased to the point that three teachers and many grades are now involved with the activities limited only by hardware and courseware availability.

Student reaction to a general question of the type "what do you think of the computer" confirmed that a positive attitude existed towards its existence in the classroom. It is noteworthy that the great majority of the students polled thought that learning with the computer was fun since it is at this level that the conjunction of the words "fun" and "learning" is most appropriate. Almost exclusively, student computer interactions resulted in success.

The use of the phrase "exposure to the microcomputer" carries negative connotations for the researcher. Derived

from the Latin "exponere", to set forth or explain, to expose carries the meaning: to deprive of shelter, protection, or care. One would hope that it is the microcomputer which is exposed to the students, not the reverse.

The researcher also is led to question the implicit assumption that "fun" and "learning" are not appropriately conjoined at the secondary school level. Evidence from the student perception study (chapter 6) clearly indicates the element of "fun" in using the computer can extend to the senior high level.

The junior high project is described as follows:

> The promotion of computer literacy at the student level is the major objective in this phase of the project. Towards this end, five computers (two purchased from school funds) are employed in both the teaching and development of an approximately twenty-five hour computer literacy module. Two groups of students have thus far benefitted from instruction through the module which stresses a "hands on" approach.
>
> Computer related instruction has proved to be an exciting, enthusiastically welcomed addition to the options offered at this junior high school. Material student enthusiasm consistently extends into non-instructional time.

It is anticipated that project related, junior high school activity will culminate with the production and compilation of resource materials which, together with proposed inservice activity, will facilitate the teaching of computer literacy at some other district schools.

Commercially produced courseware is also being used at this site to complement instruction in other curricular areas. Many teachers are benefiting from the use of the computer as an administrative aid and the general level of interest in the medium - already high - is growing.

This school was included in the current study. The progress in the science area may be inferred from a reading of the case studies in appendix C.

The senior high project is described as follows:

The five trilingual computers at this location are in constant use and support a wide variety of activities consistent with project objectives. Diversity truly is the key word here.

Localised inservicing has provided support for the successful use of a wide variety of commercially acquired courseware particularly in the areas of mathematics, the sciences and, recently, business education.

A visit to this school was unable to confirm substantial use

of a "wide variety of commercially acquired courseware" at least in the science area, although interest in instructional computing was and remains very high among the science teachers.

Staff interest in the microcomputers at this school is evidenced by their participation in the programming oriented inservices that have been offered. Approximately one third to a half of the school staff have availed themselves of this opportunity to receive instruction in the near universal language of the microcomputer (BASIC).

At present, a three part inservice/workshop featuring the use of an authoring system is in progress at the school. Ten teachers, representing five subject areas, were self selected to participate in this experience which will not only evaluate the authoring system itself but will test the viability of a relatively simple method of exploiting the potential of the computer through the creativity of the teacher.

The computers at [the school] provide an interactive computer facility for computing science classes as well as support for an extremely active computer club.

Data on the numbers of schools and microcomputers by level was provided in the report. The table has been omitted here:

Indications are that the level of interest in microcomputers is increasing at a startling rate. In order to quantify this interest and thereby assist with future planning, a survey of schools was conducted. The purpose of the survey was twofold presuming to determine both the status quo and future intentions combined with existing knowledge and are represented in the following table (further details are available).

(table omitted)

The table shows that the number of school based microcomputers is projected to increase by almost a factor of seven in a year, at which point in time [the system] will have a conservatively estimated half a million dollars invested in microcomputer hardware alone. Further indicated is that over the same twelve month period, the number of elementary schools and junior high schools employing the microcomputer will have increased by factors of fifteen and eight respectively.

By the time of the researcher's survey in February 1982, the expansion in junior highs in terms of machine numbers was at least a factor of sixteen over September of 1980.

Communication with other Alberta school jurisdictions indicates their involvement with microcomputers to be, for the most part, at an earlier evolutionary stage than [the system's]. Our district has, in fact, been able to provide a

measure of leadership in this field.

A jointly administered, Computer Managed Math Project was piloted by the Southern Alberta Institute of Technology (S.A.I.T.) and the Calgary Board of Education sometime in 1979 and featured four pilot schools. It should be noted that this project featured terminals remote from the S.A.I.T. mainframe computer.

There is microcomputer related activity within both major Calgary school districts. A fairly substantial computer literacy project was recently initiated, for example, at University Elementary School. Direct contact with one of the educational managers (planning) of the Calgary Board indicates that they are currently considering systematization of support for microcomputer users.

Red Deer City schools are very actively involved with microcomputers. Proportionately, central support for hardware for such activity has been higher than within [the system] and was preceded by appropriate inservice activity.

Evolutionary stages, like beauty, may be largely in the eye of the beholder. It should be noted that some teachers interviewed during this research study alluded to the progress made by Red Deer and decried the lack of information, courseware evaluation, and advanced support in the local area. A political view of implementation (House, 1979) would suggest that it is important that any implementation project be viewed as "the leading edge" by

its participants and administrators.

A paragraph discussion of mainframe computing has been omitted here.

The microcomputer is indisputably the current focus of attention instructionally speaking. It is a relatively low cost interactive teacher aid with the real ability to support both computing science and word processing.

The question invariably arises as to the ability of one computer to link (or communicate) with other computers. Microcomputers of "similar ethnic origin" can be made to communicate with each other almost as simply as can a terminal with the computer to which it is linked. Realistically communication between the microcomputer and the central mainframe computer is a short term impracticality (much akin to a blood transfusion from an incompatible donor).

While noting that it would be necessary to carefully examine why one would want to link to the mainframe, and expend the resources necessary to do so, the researcher finds the comparison to the blood transfusion example technically inadequate.

The report concludes:

How well we deal with the rapid rise to prominence of (micro) computers in education will depend on our state of preparedness and our willingness to assume responsibility for our own destiny. Future decisions will require a great deal of consideration and should address:

1. The provision of ongoing consultative support for existing microcomputer users.
2. The widely acknowledged (projected medium term) courseware inadequacy.
3. The level and nature of projected inservice.
4. Support for innovative activity (directed towards the needs of the gifted, learning disabled, etc. etc.).
5. Curriculum related developmental activity.
6. Projected mainframe computer activity.
7. The co-ordination of district computer activity.

Document 3

The following are extracts from a goals statement within one of the districts of the study:

Major Assumption:

The Board of Eduation [recognizes] that Computer Literacy for all students is a desirable goal for this school system to achieve in the 1980's.

Major Principles:

1. The use of computers should be available to students of all ability levels, including those with limited learning capabilities.
2. All teachers must be capable of using the computer in their classes even though they may have limited knowledge of computers and their operation.
3. Computers should be used for instruction to provide suitable skills at the literacy, competency and advanced specialty levels.
4. Computers should provide instructional support in: tutorial work, drill and practice problem solving, simulation and instructional games.
5. The computer should support instructional management through: success prediction, monitoring student progress, vocational guidance and post secondary

information.

<u>Variables for Consideration:</u>

1. Computer Hardware Requirements:
   a. Necessary sophistication
   b. Easy repair
   c. Ability to upgrade
   d. Dependability
   e. Networking capability, and
   f. Flexibility.
2. Software (programs for use) Requirements:
   a. Availability on open market
   b. Reliability
   c. Breadth of application, and
   d. Computer programming languages available.
3. Universal Teacher Expertise:
   a. Knowledge of computers
   b. Experience in computer usage, and
   c. General Knowledge
4. Application Strategy Sequence:
   a. Identify departments (or establish a new one) in which computers will be used
   b. Identify courses in which computers will be used
   c. Provide course offerings
   d. Integrate computer work into existing courses
   e. Teach using computer specialists

f. Teach using all faculty, and

g. Handle scheduling implications.

5. Cost Factors:

a. Hardware

b. Software

c. Teacher inservice

d. New courses, and

e. Availability of resources

<u>The Plan:</u>

1982/83 -teacher inservice program
-inservice hardware, software purchase
-program identification
-support for individual school projects of merit

1983/84 -continued teacher inservice
-continued hardware, software purchase
-continued program work
-continued support for individual school projects

1984/85 -hardware, software purchase
-software development support

1985/86 -hardware, software purchase
-software development support

1986/87 -hardware, software purchase
-software development support

<u>The Cost (enrolment as of September 30):</u>

1982/83 - \$10 per student Board Grant + \$3.00/student School Capital Budget

1983/84 - \$11 per student Board Grant +

	$3.30/student School Capital Budget
1984/85	- $12 per student Board Grant + $3.60/student School Capital Budget
1985/86	- $13 per student Board Grant + $3.90/student School Capital Budget
1986/87	- $14 per student Board Grant + $4.20/student School Capital Budget

<u>Anticipated outcomes after five years:</u>

1. Hardware, 1 computer/25 students.
2. Software, 1 centralized library of programs and a bank of locally developed programs.
3. All teachers capable of using computers in their courses.
4. All students having been taught the basic level of computer literacy.
5. A system wide, coordinated, sequential program in computer literacy.

Severe budget cutbacks as a consequence of the interest rate situation and the recession have apparently constrained the planned expansion. Teachers and schools which had planned for their future activities based on these projections have been somewhat taken aback by these developments. There are some indications that the schools which took an early lead within the district are now being replaced by others as the

"experts" in the technology.

APPENDIX B - Interview Guides

Interview guide - Initial Site Contact

Initial telephone contact was with the principal of schools previously identified as possessing microcomputers. The following questions were used to guide this conversation. It should be noted that these questions were a quide only. Some flexibility in wording and response was maintained consistent with the flow of the conversation.

1. I understand you are using microcomputers in the school. How many do you have?
2. How long have you had them?
3. Are they being used in science classes?
4. In what other subject areas are they in use with students?
5. Does an individual have responsibility for overseeing computer use in the school (i.e. - is there a school coordinator)?
6. Who are the science teachers involved?
7. Would you mind if I contacted them directly?
8. If it looks practicable, would you be willing to have me come out to the school for a half-day to talk further to you and those teachers involved in the project?

Teacher Contact - Telephone interview guide

1. I understand you are (are interested in) using the microcomputer in your science classes. Can you describe briefly what you are doing (are planning to do)?
2. How extensive is your program? (number of students, proportion of curriculum)
3. How frequently (will) is the machine (be) used? (constantly, frequently, occasionally, seldom?)
4. Have you encountered any problems?
5. Would it be possible to set up a time when I could come out to talk with you further?
6. It is not critical at this stage, but would it be convenient if I could time my visit so as to see the facilities in use by students?
7. Which days/times would be best?

Preliminary site survey interview guide - principals

1. How did your school get involved?
   (i.e. what prompted your involvement?)
2. How was funding for the equipment obtained? (school based budget, grant from board or province, etc.)
3. Are you working cooperatively with any other schools on this project?
4. What involvement have you personally had or do you have with the project within the school?
   (e.g. attended seminars, undergone training, committee activity and the like)
5. Have you had prior training or experience with computers prior to this project?
6. Are other administrators involved in the project? If so, how?
7. Are there mechanisms or structures in place specifically to coordinate computer activities within the schools? Is this a problem area?
8. What outside support are you getting for this project?
   (e.g. special funding, consultant support, etc.)
9. Do you anticipate expanding the use of micrcomputers in the next couple of years? Why or why not?
10. If it were an ideal world, what would you like to see two years down the road in this particular area.

Preliminary site survey interview guide - teachers

1. How did you get involved with the microcomputer project?
2. In what ways have you approached learning about using the micro?
3. Have you had previous training on or experience with computers prior to your involvement with this project?
4. Do you expect to become more involved with using computers? Why or why not? In what ways?
5. What problems have you had in using the equipment?
6. To whom or to what do you turn when problems arise?
7. How do students use the machines?
8. What materials do you have for student use?
9. What has been the student reaction to the computers generally? Are there any specific instances you can relate?
10. Have these activities affected your approach to teaching? toward the curriculum?
11. Have you done any thinking about the long term implications of microcomputers in your class? In the school? on the nature of schooling? on the nature of curriculum?

Interview guide - students

1. Do you like working with computers?
2. What do you like best?
3. What do you like least?
4. How often do you use the computer?
5. Are you satisfied with the amount of use you get? (probe here for novelty aspect)
6. How is access to the computers organized?
   - class?
   - extra hours?
   - shared/individual?
   - reserve/first come, first served - time limited?
7. What have you done related to your science program?
   - what programs do you work with?
   - do you learn when you use the computer?
   - what do you learn (value to them)?

   (if they have used simulations, how do they relate what they see to real world)

Round 2 telephone survey interview guide - principals

1. How many micros are currently in your school? Approximately?
2. How many teachers are involved in using these micros?
3. How many teachers are on staff altogether?
4. What are the primary uses of micros in your school? Science involvement?
5. How many science teachers are involved in their use? How are they involved?
6. What is being done within science classes?
7. What are the main problems that you currently face regarding use of micros in your school?

APPENDIX C - Case Studies

Case A

<u>The School</u>

School A is a medium to large high school in the urban Edmonton area. It is an older school in a "mature" area of the city. Students are drawn from a fairly broad cross-section of society. The physical facilities, typical of older schools, tend in places to be cramped although priority has been given to providing instructional space over non-instructional space. Hallways are clean and neat, with little sign of serious litter or vandalism. When classes are out, the usual groups of smokers congregate at the entrance ways. Students generally impressed the researcher as relaxed, friendly, and helpful. The researcher observed several teacher-student interactions out of class which seemed to set a tone of camaraderie among all the inhabitants of the building. On one occasion, for example, a student bounced into the office to tell the secretary how well he had done on a test. On another occasion, a student asked to use the office phone. The reply was prompt, courteous, and affirmative. This atmosphere seems to also permeate staff relations. It is perhaps indicative that the principal, whom the researcher has known for several years, has several staff members in the school who were former collegues in a previous school.

Computers are relatively new in the school, having been introduced in the fall of 1981. In February of 1982, about

21 machines were in use. The principal reports pushing on this issue, encouraging and supporting a policy of widespread and varied use. This is perhaps reflected in a distribution of equipment to different academic areas. The "traditional" computing offerings are available, including courses offered by Business Education and by the Math department. Eleven machines are in use by Electronics, and five computer synthesizers are being used for Music Education. In the fall term, the main computer lab was booked for all but two forty-minute periods of the day. The principal's interest and direct involvement is confirmed by ability to rhyme off where, who, etc.

In a quite separate activity, a computer terminal is used to access a remote career guidance data-base. While such a system is not directly part of the microcomputer implementation with which this study is concerned, it is none-the-less part of the computer "milieu" and serves to broaden the view with respect to possible computer applications in education. It is also an expensive indication of administrative commitment to technological support of the total enterprise.

<u>Science Activity</u>

In the science area, the chief activity to this point can be described as teacher familiarization. The science department has one APPLE II computer, which is housed in the departmental office. In addition several of the science

teachers actually have their own microcomputers at home.

<u>Introduction of Microcomputers in Science</u>

The head of the science department, (teacher A) together with one of the other science teachers, (teacher B) had viewed a demonstration by an Edmonton area physics teacher at a Physics Council meeting. Teacher B's son had a computer at home at the time. Seeing the demonstrations led them to "the idea that there are some things you can do in the science area ... that you can't do using A.V. or using demonstrations or labs for one reason or another...."

When the opportunity arose for some initial training in August of 1981 two of the science teachers were among the twelve teachers from the school who participated. The school board sponsored and advertised this inservice session.

Most people, with the exception of teachers A and B had never had hands on experience. Since that time three people have signed up for university courses. Another two took post graduate courses.

Teachers A and B seemed interested in using the computer directly with students but identified two problem areas. Machine resources were heavily committed to teacher familiarization, requiring restricted access for students. Much more importantly, there was a serious shortage of appropriate courseware for students:

> "...we're standing still right now, I think, in the implementation of the computer for CAI materials, primarily because of the limitation of reasonable software...".

In this school, as in all of the schools, the lack of satisfactory mechanism for evaluating courseware and software was viewed as a critical issue. They noted that one school had received software/courseware from central office because of a project that was set up. Another school, via a relative in another district, had preview access to all of the Minnesota Educational Computing Consortia (MECC) materials. The problem of reviewing software revolves around the ethics of copying combined with the vendors reluctance to supply preview copies.

> "...sometimes we have to, in the field, make a decision that says if we don't look around we won't see it and won't know if it's any good or not. And although we may not use it, and therefore we may not really deprive any royalty money coming through, at some point we have to say, is this worthwhile or not. And so I think that one of the, I hope, objectives that will be realized by the micro-computer specialist council, if not realized by the content specialist councils, will be some sort of strain of objective evaluation of this whole area."

These teachers had approached central office for evaluations and lists of available material in 1982. They expressed some disappointment both in the quantity and the quality of the information they got back.

Over the year which has elapsed since initial contact with the school, progress has been slow. Teacher B returned to university to carry on graduate work in science education specializing in computer applications. He has also been actively programming an administrative computing application for teacher use, particularly in the science area.

While his temporary absense has left a hole in the resource base within the department, evaluation of software continues. Some administrative record keeping software has been purchased, and about eight teachers are keeping their marks records on the computer. About $400.00 has been set aside in the budget to allow for courseware/software acquisitions.

Overall, the implementation of micro computers in science education at school A seems to be following a slow but reasonably steady pace. Teacher interest is widespread rather than intense. There appears to be a high level of communication among staff, departments, and administration. Expectations of progress seem to be reasonable for the circumstances. A number of unrelated but none-the-less time consuming and disconcerting events within the school during the time of the study appear to have slightly upset the schedule of computer activities, but not to a major extent. The introduction of the computer into the science classroom remains in the future, however. Problems attendant on such introduction have yet to be faced at School A.

Case B

The School

School B is a large urban high school about 20 years old. It is set in a residential area close to major commercial developments. It draws from a mixed socioeconomic group. There appears to be a considerable emphasis on formal organization and discipline in the school.

The Introduction of Microcomputers

The school has been involved in computer use since the fall of 1978, when a computing science course was introduced. This course was introduced primarily as a consequence of promotion on the part of one of the science teachers, who had taken computing science courses as early as 1971. For the first year, the sole computing support for the program was provided by the teacher's personal computer, since the school board did not supply some keypunches which they had been expected to provide. By the fall of 1981 the school obtained 2 PET computers to support the program, purchased by the Business Education Department.

The computer course was fitted into the curriculum as a Business Education course, although the teacher feels that this is a restrictive view of what the program should be.

> "...I teach certain aspects of it as business ed. Others I don't at all....I teach it as a computing science course."

> "...the mentality at the school board seems to be that this is business education course, which computing science is not."

In addition to Computing Science 30, a Data Processing 20 program was also available in the fall of 1982.

Beyond these computing courses, one Apple microcomputer, which is housed in the Industrial Arts area, was obtained under BQRP funding. Other computing activity in the school is primarily administrative.

A remote terminal is used by the administration to access the school board computer. In addition, a sophisticated stand-alone word processor is used in the school office.

Within the school, two of the vice-principals and two teachers from Business Education took a 10 week introductory course on computing given at another school. In addition, the math department funded two of the math teachers to take an introductory course at Grant McEwan. The vice-principal expressed the opinion that the science department might decide on a similar strategy.

An interesting sidelight to the microcomputer activity was the donation, to the school, of a very large card based business computer, which was installed in a business education classroom in the fall of 1981, in the expectation that it might fulfill some of the objectives of the program. The computing science teacher did spend some time with this machine, but over the summer of 1982 the administration disposed of the machine in order to make some space for 12 new microcomputers which were to be installed in the fall.

<u>Other Science Use</u>

Other than use in teaching computing science, there has been little use in other science areas. The one teacher has done some programming of Physics simulations. He feels, however, that there are two main problems associated with utilization of the computer in science: first, the number of machines that have been available have been inadequate for widespread use; second, there is very little material of quality available for instruction. While this teacher has a higher level of training and experience in the area of programming, particularly educational programming, than any other teacher interviewed in the course of this study, time is a definite problem. The time to develop software/courseware is not seen as part of the teacher's load.

> "...I think for myself at least, I'd be very happy if the board gave me say a period a day or whatever over the course of the year, so we could sit down and develop some programs."

Even with the increase from 2 to 12 microcomputers, scheduling of facilities is still tight. The administrators, in the fall of 1982, expressed some concern that sufficient extra programming access for the computing science students could prove difficult.

There was also a major physical rearrangement in the fall of 1982. Until that time, the two microcomputers used for computing science were housed in a lab-preparation area adjacent to the science teacher's classroom. These two machines were relocated into the Business Education classroom to consolidate all machines in the one room (with

the exception of the APPLE computer in the Industrial Arts area).

Case C

The School

School C is a large urban high school in a residential/commercial area, serving a student population drawn largely from a professional and upper middle class background. To the researcher, the school atmosphere appeared both less personal than school A and less discernibly discipline oriented than school B.

Micro-computers have been in use in the school for about four years. Data processing courses were already in operation when the micro's were introduced. Computing Science courses have also been introduced. These are taught within the Department of Mathematics. In addition a single PLATO terminal has been installed to assess it utility for instruction.

Microcomputers in Science

Within the science department there is a high level of professional training and experience. Some members of the department have been and continue to be very active in the area of science curricula development.

One Apple II micro-computer is located in the science preparation area. In addition there is a computer classroom currently scheduled primarily for computing science and business education courses.

Within the science area the main use of the microcomputer is for administrative assistance to the

teachers in two main areas. First, most of the teachers in the department use the microcomputer to record, store and calculate their student marks. Secondly, a large number of test items for all grade levels and science subject areas have been entered on the computer. These are used to generate quizzes for frequent class assessment. The system does not use sophisticated retrieval methods, but none-the-less provides a facility which is quite widely used. Like other teachers involved in this study, the science teachers in school C have been unsuccessful in locating much in the way of courseware/software for direct use with students. Some effective chemistry software was obtained but there are content areas where the instruction deviates from the local curriculum, thus diminishing its usefulness.

The original acquisition of the computer in science was based on the assumption that considerable use would be made of the machine for lab simulations and the like, but this has not really occurred to a substantial extent. One teacher (teacher a) indicated that booking of time in the main computer room was one serious problem:

> "...there's no way you can take a class down there and say 'Okay. As a class we're going down there and doing this two dimensional simulation on the computer' because the day you wanted to go down there..the computer room...[is] being used by Business Ed. and the Math people, and so on. They have courses which they are teaching using the microcomputers."

A mobile unit which will allow one machine and a large monitor to be rolled into science classrooms has just been

obtained. It is hoped within the department that this will increase student access, primarily for demonstrations using simulations, and for carrying out calculations to check lab results.

Case D

The School

School D is a large composite high school serving about 1800 students in a working-class section of the city. At the start of the study the school had about 20 micro computers, some of which they had had for up to three years. The chief uses for the computers were for instruction in computer education and business education. These courses were offered within the department of business education, with the bulk of the computers organized in a pair of adjoining rooms with a common entrance. The larger room housed about 12 Commodore Pets which were used for the bulk of the business education programs. The smaller room housed four APPLE microcomputers.

Although the machines had been funded by a variety of sources, they were consolidated to provide a sufficient resource to offer computer education courses.

This physical arrangement of machines was a source of some problems. Use of the facility by more than one class group at a time was not feasible. In addition, the demand for computer education courses has been sufficiently high that little free lab time was available.

At the beginning of 1983, a rearrangement of facilities has occurred which put eight Apples into a separate room. This was intended to serve as a resource room which could be used by other departments. However, a temporary shortage of space for business education courses has delayed access by other departments. The business education program requires

space for 400 students for 1983-84, in spite of entry restrictions to get into the course, which is reported to have the smallest drop out rate of any course.

<u>Microcomputers in Science</u>

Within the science department there are several interested teachers. Teacher A has been particularly active in the area, and in addition has a micro-computer of his own at home. He had developed an interest in computing and is essentially self-taught in the fundamentals of programming. In the fall of 1981, he offered a computer programming module as part of his science 21 program. The flexibility of the science 21 program made this possible.

The most difficult aspect of this endeavor was in the logistics of machine access. It was necessary to load three Apple computers onto lab carts and transport them from the computer lab to the classroom for each class period. In addition the three machines had to be shared among the entire class of students, which led to considerable waiting and some student frustration. The inclusion of such a program with the non-academic science students represents an interesting activity, however. The reactions of the students to this program are discussed in chapter 5 of this report.

Over the summer, the content of the course was revised, and it was taught by another teacher in the fall of 1982.

The science teachers have been using the computer for administrative record keeping and have been evaluating computer courseware for instructional purposes. No

significant usage of the machines for instruction in the usual content of the natural sciences has occurred as yet. As elsewhere, the lack of appropriate software and difficulty of machine access are the most frequently cited reasons.

Case E

The School

School E is a small junior high school serving a very heterogeneous student population including working class and very affluent districts. The school is about 15 years old, and is fairly typical of schools of that time. Facilities are adequate if not elegant.

The school is somewhat unique among junior high schools in that the school has been involved in a microcomputer project since mid 1980. This project was the focus of considerable attention on the part of central office consultants. A number of teachers developed technical competence with the equipment, and in fact went on to assist other schools who were just getting involved. Five teachers in this school were also participants in a study done by Travers (1981), in which a deliberate attempt was made to introduce the computer for instruction through a planned inservice program. This involved a researcher who conducted inservice work with five staff members to teach them the elements of computer programming. Instructional programs were developed for use with students.

Microcomputers in Science

One science teacher participated in the Travers study, and developed an instructional program to assist students in learning parts of the periodic table of the elements. He later took a university course to supplement his initial

training. In the spring term of 1982, there were five machines (APPLE II's) in the school. One of these was housed in the lab preparation area at the back of the science teacher's room. The courseware which the science teacher had developed was used in class by having individual students take turns while the other students continued on with their normal class activities. This was found to both disrupt the rest of the class and at the same time, cause the computer student to miss out on the regular class lesson.

The program presents 10 randomly chosen questions, of which the student is expected to get 8 right. An audible bell sounds on an error. If 8 out of 10 are answered correctly, the student is "rewarded" by being permitted to play a computer game.

The teacher has had little success in finding suitable other material for use in science lessons, and the number of machines available is a further barrier to use.

In the fall of 1982, the machines were consolidated in the industrial arts area for use in a B option computer literacy course. One machine is now located in the staff room. It is primarily used for teacher familiarization, and also to handle the administrative function of class records. The science teacher still utilizes one machine during the chemistry portion of his program, but further applications do not appear to have been developed.

Case F

The School

School F is a junior high school in a rural community of about 5000 within commuting distance of Edmonton. In the spring of 1982 the school had two APPLE microcomputers. One of these was housed in Industrial Arts, and one was housed in a lab preparation area off a science classroom.

According to the principal, about 1/2 of all the staff were using the computer for maintaining class records. The computer in industrial arts is mainly used for computer literacy training. About 120 students had hands on experience with this machine in the year 1981-82.

The science teacher (teacher A) and the industrial arts teacher were primarily responsible for exerting pressure to get the computers for the school. They in turn have provided formal inservice opportunities for other staff.

Teacher A reports considerable success in obtaining usable courseware. This was confirmed by the principal. The principal reported putting $2500 into software purchase (up to June of 1982). Through other channels teacher A obtained about three times that amount (primarily by trading with others).

As a consequence, the availability of appropriate courseware was not seen as a problem in this school. With a single machine, access was the major problem. Much of the use was by brighter students who were doing some programming. The CAI courseware was used on occasion for

remedial work. The teacher indicated that pulling students from class to do the computer work did not present a problem but that insufficient numbers of machines seriously limited what could be done.

In the spring of 1982 both teacher and principal were very optimistic about the direction of the program. They anticipated a considerable boost in the number of machines which would be supplied by the county. By fall, this optimism proved unfounded. Faced with severe budget cuts, the county cut back on planned programs. The school had anticipated getting 18 additional computers. Instead they received one. After anticipating a large increase in activity their morale was clearly affected. The teacher, who had been actively planning some external inservice work in the system decided "not to bother". The principal described their activity for the coming year as "treading water".

APPENDIX D - Humanistic use

Humanistic use - first position set

Attached are six statements concerning the human issues in the use of computers in the schools, and some possibilities that such use might bring about. There are some very real and serious concerns on the humane aspects of using computers for instruction.

Please reflect on each of these statements, jotting down any thoughts you have on each. Early in the new year I would like to briefly discuss these with you.

I will then collate all the responses and try to draw together your reactions into a new set of position statements.

From your responses to this second set of positions, I hope to devise one or more models of computer use in the schools of the future.

Position Statements:

1. In the long term a lot of people will be able to stay at home and take their courses through the computer and through video. The teacher will then make a lot more use of communication channels, as opposed to direct person to person contact.

   The atmosphere of a school is certainly a real part of students' socialization process. A lot of that will be cut back, to where kids will be out in the country and not in a four walled school.

   This may cause some problems...

2. When students learn on the computer they work at their own speed. They don't have to be stopped because the teacher says "we're going to page 100 today." Before our modern educational machine evolved, geniuses like Beethoven were people who got totally engrossed in what they were doing and there were no time limits for them. Now everything is totally compartmentalized...

3. I would like to see schools as buildings totally obsolete. Any education or information exchange doesn't happen in big packs of thirty kids at a time. Anything of value to a person is something that the person discovers for himself, learns for himself. When you're in a group of thirty you have to be part of the group, and your individuality means very, very little...

4. It's very nice to say "well, the human teacher is there for the human touch, and you walk up to one of the thirty and pat them on the back...

5. Sure its inhumane to sit a kid in a dark room and put him in front of a computer for eight hours a day,

6. What is important is that students learn to program and control the computer. It is not really legitimate to use the machine for teaching content. That is better done by the teacher...

Humanistic use - second position set

In the long term, substantial changes may occur in the organization of learning for children. While there will be much greater use of computers and other technological devices to enhance learning in the home, the bulk of formal learning activity will still occur in school settings.

agree

disagree

Comment

In the extreme case, the school setting may provide primarily the socialization aspects of learning with activites such as physical education, crafts, arts and band being the main vehicles. Children would attend perhaps one or two days per week.

agree

disagree

Comment

It seems more likely, however, that what will occur will be a greatly increased use of computers in the school both for direct teaching, and as a tool for student word processing, checking lab results, and the like.

agree

disagree

Comment

This is a preferred scenario because the socialization that occurs in school is an extremely important part of total school learning. Students learn to interact with others, and, in addition they learn the "content" of the disciplines by absorbing or selecting from other student's ideas.

agree

disagree

Comment

What is necessary is to strike a balance between direct learning from interaction with the computer and learning by involvement with the teacher and with others.

agree

disagree

Comment

Isolation in the home could lead to lessened tolerance and acceptance of others ideas, needs and desires and even to antisocial behavior. Contact in a school-like setting is an essential aspect of childrens' development. Childrens' feelings of self-worth, their recognition of "self" is

largely developed by feedback from this group environment.

agree

disagree

Comment

With increased use of the computers, there will be an even greater reliance on others for the exchange of ideas, reassurance, and assessment of one's own worth and purpose.

agree

disagree

Comment

The group setting does not hinder the development of individuals provided the numbers in the class are in the 20-25 range. Below 15 it is difficult to achieve the degree of interaction which is desirable.

agree

disagree

Comment

By use in a remedial mode, the computer can help weaker students keep pace. Complete self pacing is not a desirable goal.

agree

disagree

Comment

In addition, the current level of courseware (software) development renders self pacing impractical.

agree

disagree

Comment

In the tutorial skill learning or rememdial mode the best organization would be to have one student to one computer.

agree

disagree

Comment

For all other types of computer activities there should be at least three students per machine. Individual "carrels" such as are typically used in language labs should be avoided.

agree

disagree

Comment

While students are using computers, the teacher role will be supportive in the sense of supplying positive feedback to the students, but also tutorial in the sense of correcting deficiencies in the courseware, elaborating on concepts, and the like.

agree

disagree

Comment

This role will be more demanding of the teacher than the traditional role in the lecture situation. It will, however, closely parallel current teacher activity in laboratory settings.

agree

disagee

Comment

Access to computers will be very widespread. Students will spend about 50% of their school time engaged in computer activities, but not usually for longer than one hour at a time.

agree

disagree

Comment

The computer is only a tool, not unlike other media currently used in teaching. Although students show great enthusiasm for computers at present, the novelty will soon wear off and at that point they will be treated in the same way as books, film, TV and the like.

agree

disagree

Comment

Learning to program the computer, while worthwhile for perhaps 10% of students, is likely to be less valuable than using the computer for tutorial teaching, lab simulations, and the like.

agree

disagree

Comment

These kind of activities can be integrated easily into the existing school structure if sufficient machines and courseware (software) packages are available.

agree

disagree

Comment